Souvenir.

First District Dental Society.

DECEMBER 9, 1885.

SOUVENIR.

OF THE

FIRST DISTRICT DENTAL SOCIETY

OF THE

STATE OF NEW YORK.

DECEMBER 9, 1885.

PRESS OF PATTERSON & WHITE,
PHILADELPHIA.

FIRST DISTRICT DENTAL SOCIETY

OF THE

STATE OF NEW YORK.

Chartered and Organized in June, 1868.

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SEVENTEENTH ANNIVERSARY,

FIRST DISTRICT DENTAL SOCIETY,

STATE OF NEW YORK.

"Palmam qui meruit ferat."

PROGRAMME.

PRAYER.....BRADY BACKUS, D.D., New York

ADDRESS OF WELCOME.....DR. WM. CARR, New York

RESPONSE.....WILBUR F. LITCH, M.D., D.D.S., Philadelphia

Professor of Prosthetic Dentistry, Materia Medica and Therapeutics,
Pennsylvania College of Dental Surgery.

PAPER.

J. L. WILLIAMS, D.D.S.....Philadelphia

SUBJECT.—"The Development and Minute Anatomy of the Teeth in Health and Disease."

DISCUSSION OPENED BY

FRANK ABBOTT, M.D.....New York

Professor of Operative Dentistry and Dental Therapeutics,
New York College of Dentistry.

FOLLOWED BY

W. XAVIER SUDDUTH, M.D., D.D.S.....Philadelphia

Demonstrator of Dental Histology,
Philadelphia Dental College and Hospital of Oral Surgery.

CARL HEITZMANN, M.D.....New York

Lecturer on Dental Histology, New York College of Dentistry.

C. F. W. BÖDECKER, M.D S., D.D.S.....New York

R. R. ANDREWS, D.D.S.....Cambridge, Mass.

Lecturer on Dental Histology, Boston Dental College.

G. V. BLACK, M.D., D.D.S.....Jacksonville, Ill.

Professor of Dental Pathology and Therapeutics, Chicago College of Dental Surgery.

WM. H. ATKINSON, M.D., D.D.S.....New York

FIRST DISTRICT DENTAL SOCIETY.

Special Anniversary Meeting, Wednesday Afternoon and Evening, December 9, 1885, at Mazzetti's, Nos. 100 and 102 West Forty-ninth street, New York City. The President, Dr. William Carr, in the chair.

THE proceedings were opened with prayer by the Rev. Dr. Brady Backus, of New York.

President William Carr delivered the following address:

President Carr. Seventeen years ago a few earnest men met at Cooper Institute and organized the First District Dental Society of the State of New York, electing Dr. A. L. Northrop its first president. A law had been recently enacted in this State which gave dentistry a legal status. Prior to that it had none. Then it was too often customary for persons who had failed in other vocations to turn to dentistry as a respectable means of gaining a livelihood, and, by a few days' or a few weeks' preparation in a dental office, to launch out into the world as full-fledged "dental surgeons." At that time our meetings were small, and but few of the representative dentists of our city took an active interest in our society. The subjects discussed were usually of a mechanical, not of a scientific, nature. Our colleges were but few and the curriculum limited. Then we were obliged to look to Europe for our knowledge of histology, pathology, and many of the higher branches of our specialty. Mark the change! At our meetings the attendance, instead of numbering from ten to fifteen, has steadily increased until, during the present year, the average attendance at our regular meetings has been one hundred and thirty. With this steady numerical growth there has been a corresponding increase of activity among the members, each vying with the other to contribute his mite to the science and literature of our profession. This activity has been stimulated not only by the interchange of ideas, and the candid statement of practical difficulties which each is called upon to meet and treat intelligently in his own special practice, but also by an

increase of knowledge due to the wider range of thought induced by researches into the domains of science, especially with the aid of the microscope, which has revealed many facts heretofore hidden from our vision.

As regards our colleges, we find that one or more dental colleges have been established in nearly every section of the Union, as the direct result of the enactment of dental laws in nearly every State and in some of the Territories. These laws clearly define the requisites for a dental practitioner, and they protect the interests both of the practitioner and of the public. With this increased number of colleges the standard of dental education has been raised. And I am happy to express my belief that this society has been one of the important factors in effecting these results, of which we should justly be proud.

Gentlemen, I congratulate you upon the harmony and good-fellowship that exists among us as a society, and trust that this good-fellowship may continue, and that we may increase in knowledge and usefulness.

Gentlemen who are our guests, we are proud to extend to you a warm greeting and a hearty welcome. It is a pleasant privilege for me, as president of this society, to welcome so many gentlemen of recognized ability and worth from sister cities, who have so kindly and generously consented to come, and to give us the benefit of their investigations on this occasion of our anniversary. We appreciate the sacrifices that you have made in leaving homes and business at this season of the year, and we cordially invite you to participate in our discussions with the same freedom and earnestness that you would exercise in your own societies. Again, gentlemen, we welcome you!

The President then introduced Dr. Wilbur F. Litch, of Philadelphia, who spoke as follows:

Dr. Litch. Mr. President, it is with sincere gratification that I rise to thank you on the behalf of those who, like myself, are invited guests at this meeting, for the words of cordial welcome which you have pronounced. The First District Dental Society of New York has long been known as one devoted to practical work, and the clinics which have been held under its auspices are justly regarded as among the important educational influences of the day in the domain of dental art. It is a pleasure to recognize the fact that the usefulness of the society and the number of its members were never greater than they are now, and that as it approaches the period of legal manhood, now but some four years distant, it is

displaying an exaltation of purpose and vigor of action which presage long years of usefulness to come.

I have spoken of the society as being eminently practical in its work; yet we have assembled here, some coming from distant States, for the discussion of a question which to many minds may appear as remote from the domain of practical dentistry, from the standpoint of the mallet and the plugger, as to other minds the speculative theories of the political economist, or even his exact deductions, may be deemed foreign from the domain of practical politics; the condemnation of both being summed up in the one phrase, "they are not business." It can hardly be necessary, in this presence, that I should enter into a dissertation on the importance of scientific truth as such because it is truth, and not simply for the dole of dollars that it will yield.

Bacon has finely said, "Just as we are deeply indebted to the light because it enables us to enter on our way, to exercise arts, to read, to distinguish one another; and yet, nevertheless, the sight of light is itself more excellent and beautiful than the manifold uses of it. So assuredly the very contemplation of things as they are, without superstition or imposture, without error or confusion, is in itself far more worthy than all the produce of discoveries." And yet, apart from the grandeur of its simple contemplation, there is in science no truth, however abstract in its seeming, which has not, or may not have, its practical bearing. No ascertained fact in any science can be safely ignored, because while isolated it may appear devoid of all practical significance and value, yet when joined to other things, known or knowable, it may prove to be the one connecting link in the chain of inductive thought beneath the flash of whose subtle currents new forms as from a menstruum are precipitated from the creative brain, and new-born knowledge, Pallas-like, again step forth, as in the myth she sprang from the forehead of her sire. More and more surely is it becoming known that the law of the atom is the law of the sphere, the law of the cell the law of the organism, and that we can never grasp the full meaning of the infinitely great until we have read the riddle of the infinitely little. From this stand-point, then, the object of this meeting is far from being impractical, and whatever light may be thrown upon the law of the little as related to dental histology and dental pathology by the essay and discussion to which we are to listen, and from which I will no longer detain you, cannot fail to be of service to science and mankind.

President Carr. Gentlemen, we now invite your attention to the reading of a paper by Dr. J. L. Williams, of Philadelphia.

THE DEVELOPMENT AND MINUTE ANATOMY OF THE TEETH IN HEALTH AND DISEASE.

Dr. Williams. Mr. President and Gentlemen: If I acknowledge the feeling of weakness which often prompts men to shrink from the consequences of placing themselves in a position where they are likely to be misunderstood or misinterpreted, I must also plead the extenuating circumstance that such feeling of weakness is born of past experiences, which have taught me that there are but few men who are sincerely grateful to those who point out their errors of opinion or belief. This is especially true of those who enjoy something of an intellectual reputation which may be founded, to a greater or less extent, upon such errors. Therefore, to criticise with perfect frankness opinions which have become a matter of fixed intellectual pride is often regarded as an injudicious proceeding.

There is too frequently evident in all critical efforts a quality which has regard chiefly for that artificial adaptation to environment known as expediency,—an attempt to conceal more than is revealed, but often to those who read between the lines revealing more than is concealed.

It is the rare exception that discussions of questions of truth or error before scientific or professional associations are free from that exhibition of intellectual gymnastics which seeks by some trick of voice, or emphasis, or rhetoric, or what passes for logic, to win the applause of the moment. At the last, however, only the simple truth remains, and we shall all probably come to see that this exists quite independently of our intentional or unintentional efforts to elucidate or obscure it. But if I correctly apprehend the purposes of those who are to take part in this discussion, the meeting is destined to be a memorable one; and I trust that it may also prove a dignified exception to many former experiences in being animated by and conducted in that spirit of kind earnestness which should actuate all fellow students and lovers of the truth.

The principal object of this essay, as announced, is the consideration of certain features in the minute anatomy or microscopic morphology of the dental tissues in health and disease.

The reason why I shall preface this consideration with some remarks on the development of the teeth, is that I have grown more and more to see the futility of any attempt to arrive at unanimity of opinion concerning either morphology or function, except through a careful study of the history of the development of the organism; and not only of the individual organism, which is the immediate object of our studies, but of the lower forms of life which lead up to it.

While I cannot believe that these higher and more complex

organisms have evolved themselves by a process of slow but continuous development from a more lowly condition, but rather that the creation of each succeeding higher form of life has been effected by the superposition, or rather the infusion, of a higher quality of life-energy from the source of all life, yet I cannot but recognize that there is an intimate bond of relationship between all forms of life, and that, as I have before said, the complex and oftentimes obscure conditions which prevail in higher forms of life are expressed in simpler and therefore more easily comprehended terms in lower forms. Therefore, I repeat a statement that every biologist of note of the present day will confirm,—a comprehensive knowledge of the structural relationships and functions of an organism is only to be gained by a careful study of the history of its development, both from the stand-point of ontogeny and philogeny. This statement is quite as applicable to the teeth as to the organism as a whole or to any of its parts; and upon it are based the views presented in this paper.

There is one other principle to which I wish to call your attention, and the importance of which I wish to emphasize. It is that, while the organism is developed and exists as a unity, while it is inter-dependent in all its parts to the extent that every molecular change which occurs in the finger tips modifies, in its degree, other changes which are occurring in remote parts of the body, yet the development and maintenance of every part is under the special domain of its own inherent typal energy and environment. There are individuality and structural peculiarities as well as unity in development, and this in accordance with the function or use to be performed. This principle has not been observed by those who have carried similarity of development, structure, and function so far that it has become identity. The importance of this point will be seen as we proceed.

If I were asked to express in a single sentence all that is meant by the term development as applied to animal organisms, I should say it is the focalizing of life energies in certain territories in accordance with typal ancestral endowments and limitations. In elaboration of this, I would say that, in the development of complexity from simplicity of structure, the first observable departure from uniformity is an increased activity in the formation of the elements or corpuscles at the point where the new departure is to take place, or the point from which the development of the new organ begins. And I would characterize the initiative impulse which leads to this more rapid cell-proliferation, as it is usually called, as the focalizing of life energies at this point. It is the formation of a new center from which the circumference of the new organ will be unfolded, and this in accordance with that great universal law, applicable

alike to corpuscle, organism, or world,—"creation proceeds from center to circumference."

As the germ of every human tooth springs from two distinct sources, it may be said to have two centers of origin,—the first arising in the epithelial layers, from which the enamel-organ is developed; the second from the underlying dermal tissue, from which the dentinal germ is developed. It may be well, at this point, to call attention to one of those errors of comparison to which I have referred. In a recent work on histology by a high authority the statement is made that teeth are developed in the same manner that hairs are. Other writers have asserted that the process of development in nails, claws, hair, and teeth is the same. Such statements show both a lack of close and careful observation and an absence of fine perception of what development means. They have simply glanced at the surface and seen certain similarities, and they go away and say the processes are the same. They seem not to know that if the processes by which a tooth is developed were the same as those that result in the formation of a hair, there would be in the end not a tooth, but a hair. There are important differences in the methods of development, and those differences are determined by the function or use which each organ or appendage is destined to perform. While from observation we can predicate nothing from the appearances of these centers of development at the commencement of the process, yet we may see, if our observation be carefully continued, that differences become more and more apparent at each succeeding stage, and we know that this is determined at the beginning.

It is not necessary for the purpose of this paper to go over all the ground of the evolution of the dental tissues. Permit me, then, to call your attention at once to this illustration of a developing tooth at the commencement of the process of calcification of the dentine and enamel. You see here the dentine and enamel-pulps inclosed in a sac, in which these processes are taking place. This sac was for a time connected with the epithelial layers of the mucous membrane by means of a tubular cord of epithelium. This cord was simply an elongation of the primitive bud from which the enamel-organ is finally formed. After the developing tooth is completely inclosed in its sac this epithelial cord is broken up, and there is seen to result from its breaking up little whorls or globular masses of these epithelial corpuscles.

As there is a deeply interesting subject which may have some connection with this disappearance of the enamel-cord, you will permit a little digression here. You know we not infrequently find departures from the normal number of teeth in the mouth; we find extra

or supernumerary teeth, as they are called. We also sometimes find teeth developing in other parts of the body. I have here for your examination some specimens of quite perfectly formed teeth which were taken from an ovarian cyst. The question at once arises in our minds, What antecedent conditions have led to the formation of these supernumerary teeth, whether in the mouth or in locations remote from their usual position? In the development of the second and third molars we observe that the germs from which they grow arise as buddings from the cord of the first molar germ; the cord of the second molar arising from that of the first, and the third from the second. This has led to the conclusion that under certain conditions any portion of the epithelial cords of the tooth-germs may develop into an enamel-organ or pulp. We have also observed that a dentinal germ is always formed directly beneath the enamel-pulp wherever it drops down into the dermal tissue. It thus seems that the presence of the enamel-pulp is the immediate antecedent of the dentinal germ. This view is confirmed by the fact that in the formation of the teeth of some of the lower forms of life, in which the fully-developed tooth has no enamel, there is, at the commencement of the process of development, the correlative of what becomes the enamel-pulp of the teeth of higher organisms. This is very strong evidence that the presence and position of an enamel-pulp determines the formation of a tooth at that point. This is a beautiful illustration of the statement before made, that in the endeavor to unravel the complex relations existing in the higher organisms we are often greatly assisted by a study of the lower forms. Now, if any portion of the enamel-cord may develop into an enamel-pulp, and if the enamel-pulp determines the formation of a tooth, then there is a reasonable probability that those little whorls or globular masses of epithelium which result from the breaking up of the enamel-cord may, under unusual conditions, result in the development of a tooth, and that these globular epithelial masses may be carried to remote parts of the body and there result in the formation of teeth. You may object that there are too many "ifs" and probabilities surrounding this question; but I have only to reply that, in the absence of all positive knowledge, the highest probability stands as the next best thing, and the whole theory of evolution and many other modern scientific doctrines rest on a less secure foundation.

It is but proper to mention, however, that there is another theory for the formation of teeth in ovarian cysts, which is that in the formation of the embryo some portion of the epiblast in the region of the mouth becomes caught and infolded within the body cavity as the body walls close together. If we turn now to our illustration of a

developing tooth, we observe that it is completely surrounded by a sac composed largely of spindled-shaped connective-tissue elements. We see that its vascular supply is concentrated at two points,—in the dentinal pulp and around the enamel-organ; and this is precisely what we should expect, for the one is the formative organ of the dentine, and the other of the enamel. It is seen that the formation of dentine begins at the line of its junction with the enamel, and proceeds inward and downward, and that the formation of enamel begins at the line of its union with the dentine and proceeds outward. I believe there are those who do not regard this as the manner in which these tissues are formed. But there is such unanimity of opinion among those who have done any considerable practical microscopical work in this direction, that it is hardly worth while to discuss the point with those who would not care to be known as holding critical views on the development and histology of the teeth.

What is the process by which dentine and enamel are formed? We now approach the consideration of an important question, and the one upon which my criticism of well-known and popular writers upon the histology and pathology of the dental tissues is largely based. The formation of dentine begins shortly before that of enamel, and its first appearance is that of a cloudy, cartilaginous-looking line, which is seen just outside of the odontoblasts, occupying the most prominent point or points in the developing tooth. At the same time delicate fibrillæ are seen sprouting from the outer ends of the odontoblasts. As this line of forming dentine increases in thickness the odontoblasts are observed to always remain just beneath it. It is probable that the increase in thickness of the dentine is effected by the continued secretion of the cartilaginous matrix, which has been called calco-globin, and the almost simultaneous deposit of the mineral constituents in this matrix. The forming line of dentine is probably pushed upward and outward by the continued deposit from the odontoblasts. As the process approaches completion the dentine is also increased in thickness from within, thus reducing in size somewhat the pulp,—at least that portion which remains in the roots. The growth of the fibrillæ corresponds with the increase in the thickness of the dentine, although they sometimes seem not to be governed by this condition, but grow on and penetrate between the ameloblasts, which lie just outside of and in contact with the dentine. This penetration of the ameloblastic layer by the dentinal fibrillæ is probably always effected before the deposit of enamel begins. These dentinal fibrillæ sometimes continue to grow, their terminal points keeping just in advance of the outer line of forming enamel, so that when the enamel is

completely formed its entire thickness is traversed by these fibers. This is not of common occurrence, but I think it can hardly be regarded as a departure from normality, for I have many times observed the dentinal fibrillæ penetrating the entire thickness of the enamel in the teeth of animals.

Every appearance of the formed dentine in health and disease, and every phase of its development, contra-indicates the view that it is built up by the calcification of layers of odontoblasts or dentine corpuscles. If this view were correct, we should everywhere see partially calcified corpuscles, which we never do. The line between the forming dentine and the outermost layer of the odontoblasts is always strongly and sharply marked. There is no other possible way of explaining the continuity of the dentinal fibrillæ, now that it is demonstrated beyond all possibility of doubt that they are offshoots or prolongations of the odontoblasts. The building up of the dentine by calcification of the successive layers of corpuscles was necessarily accompanied by the theory that the dentinal fibrillæ were offshoots of the reticulum of the pulp, which offshoots passed between the odontoblasts into the dentine. The demonstration of this error removed the only foundation upon which that whole theory rested. The most logically constructed theory becomes valueless when the premises upon which its first postulates rest are disproved. I know that many regard all scientific theories as matters of minor importance. But when we realize that the entire practice of medicine, involving as it does the great practical questions of human life and happiness, rests almost entirely upon theory, we see the importance of applying the most rigid tests to all assumed basal principles. Our practice must depend upon our perception of pathological conditions; and the clearness of our perception of these conditions grows out of our knowledge of structure and function, and this knowledge, we are growing more and more to see, rests largely upon the history of the unfolding or development of the organism. I do not wish to be understood as passing any criticism upon the teachings of the honorable gentlemen whose theories I am considering, except so far as they have relation to the development and histology of the teeth. I must regard these teachings as in many respects erroneous, and in other features as giving undue importance to and emphasizing certain points in the histology of the teeth which have long been familiar to practical microscopists in this field. It is a tendency not infrequently manifested by scientific workers in special directions to so magnify the importance of some particular aspect of the truth that it is distorted out of all relation to the many qualifying truths to which it is related. It has been assumed that because bone and cementum are formed by the calcifi-

cation of globular territories, and because dentine bears some slight resemblance to bone and cementum, therefore it is built up in a similar manner. This is but another evidence of that hasty deduction from inadequate study of which I have already spoken. Many writers have labored to draw the most absurd comparisons between bone and dentine. But dentine remains dentine just the same, and the difference in the completely developed tissues is the correlative of the difference in the methods of their development. In the development of bone, and to a considerable extent in cementum, the original osteoblast or cementoblast remains as the persistent center of the calcified territory, and the source from whence its continued integrity is maintained. Now, in dentine the only thing corresponding to this persistent center is the dentinal fibrillæ. But the dentinal fibrillæ are continuous processes running from the odontoblasts on the surface of the pulp through the entire thickness of the dentine to the enamel. Neither are they the center of what was once a larger territory occupied by the odontoblast, as I have shown when speaking of the growth of the fibrillæ. By a process of reasoning by exclusion, and by the evidences shown by the microscope, we reach the conclusion that the formation of dentine is effected by a process of continual deposit from the enamel inward, until the typal demands of each tooth are satisfied. One other fact, which in itself is sufficient to demonstrate the impregnability of this position, is the free branching of the fibrillæ at their terminal points, while in the deeper layers of the dentine and in the region of the pulp-canal it is far less marked, and in many cases there is almost an entire absence of this branching. There is one other feature of the histology of a developing tooth which, if carefully studied, will also demonstrate the impossibility of the theory under criticism. The odontoblasts, as before mentioned, are observed to send a varying number of fibers into the dentine, five or six of these fibers sometimes arising from a single corpuscle. These corpuscles or odontoblasts are also observed to be connected with the pulp reticulum by root processes arising from their inner ends, and these latter processes do not correspond in number with the dentinal processes arising from the same corpuscle. If the dentine were formed in the manner described by Dr. Heitzmann, there would be great irregularity in the direction and arrangement of the dentinal fibers; which is not true, the arrangement and continuity being, in normally developed teeth, uniform throughout the entire thickness of the dentine.

The enamel is formed from the ameloblasts. These bodies are derived from the Malpighian layer of the epithelium of the mucous membrane. They are the active secretory elements in the forma-

tion of enamel. I have in former papers pointed out the relationship existing between the enamel-organ and other glandular bodies derived from the epithelium. As before mentioned, and as beautifully shown in the drawing, there is a free supply of blood through an intricate capillary plexus surrounding the enamel-organ.

The precise part played by the reticulum or interior portion of the enamel-organ in the development of enamel has not yet been fully determined, but it is quite probable, as pointed out by Dr. Sudduth, that the presence of the reticulum of the enamel-organ is not necessary throughout the entire process of enamel formation, but rather that it is a matrix or receptacle in which is stored and partly elaborated the material for the commencement of this process. But the fact that we find, in sections of the persistent growing teeth of the Rodents, this same reticulum of the enamel-organ is a demonstration of its importance. In the formation of enamel the error of the teachings of Dr. Heitzmann is even more evident than it is in dentine. There is never to be seen but a single layer of the prismatic enamel-cells which surmount and surround the forming enamel. The line which separates the ameloblasts from the forming enamel is even more strongly marked than in dentine. There are, however, important differences between the formation of enamel and dentine. Transverse and longitudinal sections of enamel show that it is built up in the form of prismatic elements, which have a wavy and also in some locations—notably on the points of the cusps —a spiral arrangement. Now, we know that the functional activity of every corpuscle proceeds from its center outwards, the circumference being less highly endowed than the center. We have seen that the ameloblasts constantly recede outward before the line of advancing enamel-formation. We know that the enamel-rods, as a rule, are continuous throughout the entire thickness of the enamel, and that each enamel-rod is ensheathed in a substance differing in appearance from the rod itself. This covering of the enamel-rods is also the cement-substance which unites them.

It seems that as the ameloblasts recede or grow outward they leave behind, in the forming enamel, the intra-cellular cement-substance which forms the low-grade fixed material of which the external of every enamel-rod is formed, and this constitutes the matrix of the enamel into which the active functioning portion of the ameloblasts deposits the phosphate of lime and other mineral elements.

If the cell of the honey-bee were continuous throughout the entire thickness of the comb, and had that same wavy and twisted arrangement which the enamel-prisms have, it would form a beautiful illustration of the structure of enamel; the waxy substance of which

the wall of these cells are composed corresponding with the organic matrix or inter-prismatic cement-substance of the enamel, and into this organic matrix the ameloblasts deposit the mineral constituents, as bees deposit honey in the wax-cells of the comb. This view is confirmed by all the appearances of developing enamel, and necessitates no departure from the functional order of every morphological unit of which the body is composed. As the formation of the enamel-prisms proceeds outwards, and as these prisms are not perceptibly larger at the circumference than at the line of union with the dentine, we may see that, if there were only a limited and definite number of enamel-formers or corpuscles at the commencement of the process, as the enamel-cap is a modified sphere, there would be everywhere throughout its substance cone-shaped cavities. Extra or supplementary cells are therefore provided for the filling-in of these widening spaces, and in longitudinal sections of enamel we may see where this process begins. These extra cells probably arise by division of the ameloblasts. But it should be remarked that this same appearance may be caused by the twisted enamel-rods coming into view just at the point where the section was cut. Many absurd blunders of interpretation arise from regarding the plane of the section as a complete picture of the entire structural arrangement. The enamel-organ is sometimes spoken of as having a stirrup-shape, from the appearance of a section, when it is, as a whole, an invaginated, modified cone or sphere. What Dr. Abbott has illustrated in Fig. 4 of his recent paper on the pathology of enamel as an abnormal, irregular arrangement of the enamel-prisms is due simply to the specimen having been cut through a territory where the forward direction of the enamel-rods or prisms was diverted by the spiral arrangement of which I have spoken. I have many times seen the same appearance in normally developed teeth. In truth, this arrangement of the enamel-prisms is one calculated to give the greatest possible amount of strength, and is, as I have remarked, found at those points which must maintain the greatest resistance in mastication. We should therefore always expect to find such an arrangement in teeth of the highest organization—an anticipation which, I believe, careful observation will confirm. Neither can I regard the stratification or pigmentation of enamel, as elaborated in Dr. Abbott's recent paper, as a matter of much importance from a pathological stand-point, for these appearances are common in the teeth of animals in which caries is never found, so far as I am aware. As the formation of enamel approaches completion we find that the ameloblasts gradually disappear. We have observed, during the formation of enamel, a layer of flat cells lying just outside the ameloblasts. This layer of cells I believe to be hardened

by direct calcification as Nasmyth's membrane. It is this layer of flat, calcified epithelial elements which gives the glossy, polished surface of perfectly-formed enamel. This layer has been supposed by some to be a continuation of the cement-forming organ. But this is a mistake. The cement-forming organ is a modification of the original tooth-sac, and, as this sac extends completely over the enamel, some portion of it may become infolded in the formation of the sulci of the teeth, and then be stimulated, perhaps by the supply of lime-salts, to the formation of cement territories in the depressions of the molars and bicuspids. But the calcified layer of cells forming Nasmyth's membrane will never, I think, be found outside of these cement territories. All of that portion of the tooth-sac which covers the crown usually disappears, or is modified, as I think, into the so-called *ligamentum dentium*, without assuming that function which is the special work of the lower part from which the cementum is formed, and which remains as the peridental membrane or pericementum surrounding the completely-formed root. No one who has studied the development of this last-mentioned tissue could be led into the error of speaking of it as a double membrane. It has, as I pointed out in my earlier papers, a double osteogenetic function—that is, the inner portion lying next the cementum contains the cementoblasts, while the outer portion lying next the alveolar walls contains or consists of the osteoblasts or bone-forming cells. But no misuse of terms and comparisons can construe its significance into that of a double membrane.

From this slight digression we again turn to a further consideration of the structure of enamel and dentine in health and disease. I must deny *in toto* the theory that there are special enamel-fibers in the sense that the prolongation of the odontoblasts are fibers.

Enamel is, as we have already seen, formed in an entirely different manner from dentine. Dentine is formed in territories of which the odontoblast fibers are the centers. The method of the formation of enamel is quite the reverse of this, for the only portion of enamel which can be spoken of as organic *surrounds* the enamel-prisms. When enamel is cut longitudinally there *is* an *appearance* of fibers, but it seems very strange that those who have written so much about enamel-fibers have not seen that this appearance results from the division of this organic matrix which surrounds each prism. A transverse section demonstrates this, and it is a notable fact that the only transverse section of enamel shown in Dr. Heitzmann's book presents no appearance of these hypothetical enamel-fibers. Such an appearance would be utterly inconsistent with the method of development and arrangement of the enamel-prisms, and yet these fibers are shown in all of the longitudinal illustrations.

There is sometimes, though not frequently, observed in developing teeth, where the enamel-forming cells are pulled away from the partially calcified enamel, an appearance of fibers. I have also occasionally seen in developing teeth an appearance, in cross or transverse sections, like a nucleus in the center of the enamel-rod.

Dr. Sudduth's explanation of this appearance is so concise and clear, and so in harmony with my own observations, that I quote from him. He says, when speaking of the ameloblasts being torn from the semi-calcified mass of forming enamel, "This semi-calcified material, which adheres to the ameloblasts" as they are drawn out, "gives the appearance of a fibril or prolongation of the cells themselves. These fibrils, which have been called Tomes's processes, I consider as thus being mechanically made, for they do not always appear, but depend upon a certain condition of the calcific material. They do not occur persistently, as do the fibrillæ of the odontoblasts, I have succeeded in demonstrating them in sections of pigs' teeth, under favorable circumstances, where they showed very plainly indeed, being nearly or quite as long as the ameloblasts themselves, *and several times longer than the enamel was thick.*" It is as though one were to dip the ends of one's fingers in a thick syrup, and on withdrawing them the syrup would be drawn out in strings as the ameloblasts draw out the gelatinous matter on the surface of forming enamel. This is the only appearance of fibers to be seen, and this only in forming enamel. It is therefore seen that this appearance has nothing in common with the so-called enamel-fibers described in Dr. Heitzmann's work. To what conclusions are we forced by the evidence? That enamel, once completely developed, undergoes no structural change during life, and probably no molecular change,—at least, not in that portion which constitutes ninety-seven per cent. of its composition. There is the highest probability that all changes which occur in enamel are the result of the slightly increased or diminished amount of fluid which may penetrate from the dentine or the surface. The human body is not the scene of a hodge-podge of physiological activities. There is order and exactness everywhere. Bile is not secreted in the kidneys if the liver happens to be out of order; neither will the lungs elaborate chyle out of food-material when the digestive tract refuses to perform its functions. There is intimate relationship and mutual helpfulness everywhere, but if evolution and development mean anything they mean division of labor and specialization of function. Dentine is not formed from osteoblasts or cementoblasts, nor is cementum formed from the odontoblasts. Neither can the material from which enamel is built up be elaborated in any other way than through the ameloblasts. How careful the surgeon is to preserve

the periosteum if he desires a reproduction of bone! He knows, if its formative organ is destroyed beyond recovery, that there will be no further reproduction of bone at that point. Now, it must be remembered that enamel is the only tissue of the body the formative organ of which not only disappears, but the enamel itself is removed from the position of its development and completely isolated from all tissue concerned in its formation. This is a fact of great signifi-cance, and places enamel in a unique position, physiologically speaking, in which it cannot be compared to any other tissue in the body. The odontoblasts and their processes, the fibrillæ, are the elements by means of which the dentine is formed, and they remain after development is completed to maintain the continued integrity of the dentine. And thus it is also with bone and cementum, the formative organs of which remain as the source from whence these tissues receive their nutritive supply. Not so with enamel, however. The ameloblasts are the enamel-formers. Its peculiar morphology and its molecular structure are impressed upon it by these histological elements. They completely disappear, after which there can be no further formation of enamel. We have no evidence of structural change in enamel after the eruption of the teeth, and structural change, by which I mean change in molecular relationship, is the only change which could improve defective enamel. The apparent increased or diminished liability of the teeth to decay during life must be very largely attributed to changes in environment, changes in the character of the secretions and fluids of the mouth, rather than to any inherent change in the enamel itself. An increased proportion of organic matter in enamel, within certain limits, by no means necessarily implies increased liability to caries. Every closely-observant dentist knows that a departure from the proper proportion of organic and mineral matter in either direction may result in increased liability to decay. But every dentist of thoughtful experience also knows that more depends upon that initiative organizing force which governs the formation of enamel than upon any changes which ever occur during life. The fact that teeth which are *well* developed will endure the adverse conditions of a lifetime without serious damage, and on the other hand the fact that teeth poorly developed cannot be changed into teeth of excellent structure, at least so far as the enamel is concerned, by the continued good health of a lifetime, is very strong evidence of the truth of my propositions. Understand me. I say that those improved conditions which we all observe and which decrease the liability of the enamel to caries are largely, probably entirely, due to changes in the environment of the teeth rather than to any change in the structure of the enamel. In truth, change in environment is alone quite sufficient to explain the

decreased liability of the teeth to decay. There is no one in our profession to-day who has done more thoroughly scientific work in the investigation of caries than Dr. Miller, of Berlin. I can hardly speak too emphatically of my appreciation of his labors. Dr. Miller's investigations have demonstrated, to the complete satisfaction of any mind which can appreciate the significance of genuine scientific work, that the active immediate causes of caries are acids,—largely those generated in the mouth by fermentation,—which cause decalcification of the mineral constituents, and certain micro-organisms, which destroy the organic matter. Any change, therefore, whether in the nature of local prophylactic or antiseptic treatment, or general systemic treatment, which removes or improves those conditions which are favorable to the formation of micro-organisms, is quite sufficient to explain all decreased liability of the teeth to decay. The statement made by Dr. Abbott in his recent paper, that the increased liability of the enamel to pathological changes which is observed as accompanying change of climate and food-habits is due to changes in the living matter of the enamel, will not for a moment bear the light of real scientific investigation. In former papers, and in his chart representing section of an incisor tooth *in situ*, Dr. Abbott claims that embryonal or medullary corpuscles are formed in the retrograde metamorphosis of enamel. Dr. Heitzmann also teaches the same doctrine in his book. It might be regarded as needless effort to do more than demonstrate that such a retrograde process is impossible from the stand-point of the method of development of the teeth, as I have already shown. But the so-called inflammatory theory has taken such a strong hold upon many in the profession that it can only be uprooted by placing the absurdity of its claims in the strongest possible light. It may be that in the decay of living teeth in the mouth there is a condition which is the correlative of inflammation in the soft tissues, although the relation is probably very distant and obscure; but this point, if admitted, has no bearing upon the appearance of medullary bodies in caries of enamel and dentine.

In the sixth statement of his summing up of his series of papers on the relation of fermentation in the human mouth to caries of the teeth Dr. Miller says: "I produced caries artificially, which, under the microscope, cannot be distinguished from natural caries, by subjecting sound dentine to the action of these fungi in fermentable solutions." Dr. Sudduth will place under the microscopes for your inspection some of these slides kindly sent me by Dr. Miller, and also some of his own preparation, showing natural and artificial decay of dentine. You will see that it is, as Dr. Miller says, impossible to tell from the microscopic appearances which was

naturally and which artificially produced decay. It can hardly be necessary for me say that no intelligent person would think of making the statement that a dead tooth out of the mouth could return to an embryonal condition. If, then, it is not possible to tell by microscopic examination natural decay from that artificially produced, what becomes of the inflammatory theory of decay? If Dr. Miller's work has *any* value, if *any* conclusions may be drawn from it, then he has certainly demonstrated that the return of dentine and enamel to an embryonal condition, even if these tissues were so built up, is an impossibility; but, as we have already seen, the tissues are not so formed in the beginning.

Let us consider the question from still another stand-point. The dentine of adult teeth may be said to contain from seventy to seventy-two per cent. and the enamel from ninety-six to ninety-eight per cent. of mineral matter, principally phosphate of lime. The appearance of embryonal elements in enamel or dentine means not only the liquefaction, but, to a great extent at least, the decalcification, of these tissues. We might very pertinently inquire how this delicate matrix of living matter, constituting in enamel but three per cent. of the tissue, can be made to fill these decalcified tracts. It is asking quite too much of a tissue which it is doubtful if the most delicate methods of decalcification can discover. In an illustration accompanying one of Dr. Abbott's papers the region of enlarged canaliculi, which enlarged canaliculi are represented as filled with nucleated bioplasson bodies (and the statement that they are nucleated means that the living matter has undergone a complete re-organization), corresponds exactly with the infected region of Dr. Miller. The enlarged canaliculi are everywhere filled with micro-organisms, which destroy the living matter as fast as the acids effect the removal of the lime-salts, thus giving it no opportunity to be re-organized into medullary corpuscles. In fact, these micro-organisms, in destroying or digesting the living matter, effect this enlargement of the canaliculi, and it is these enlarged canaliculi filled with micro-organisms and débris, that Dr. Abbott has mistaken for fields of nucleated bioplasson and medullary corpuscles.

Gentlemen, the demonstration is under the microscopes; examine the specimens for yourselves. But keep in mind the fact that I rest my case upon the evidence shown in the development of the teeth. This evidence I regard as conclusive and impregnable. To recapitulate, then, the points against Drs. Heitzmann and Abbott:

1st. In the formation of dentine there is never to be seen any evidence of the coalescing of odontoblasts or dentine corpuscles.

2d. There is never to be seen any indication of partially calcified corpuscles; on the contrary, the line which separates the forming

dentine from the odontoblasts is always strongly marked, and these tissues are affected by staining agents in an entirely different manner.

3d. There is not uniformity in the branching of the fibrillæ, this peculiarity being much more strongly marked at their terminal points than in the deeper parts of the dentine.

4th. The dentinal fibrillæ are processes of the odontoblasts, and are continuous, passing from these bodies through the entire thickness of the dentine without break in their continuity.

5th. There is no perceptible material change in the appearance of the odontoblasts, from the commencement until the completion of the formation of the dentine, except that they seem to decrease slightly in size as the process of dentinification approaches completion.

6th. The microscopic evidences that enamel is not formed by a calcification of successive layers of corpuscles are more clearly shown than in the formation of dentine, there being never but a single layer of ameloblasts outside the forming enamel, and the line which separates the enamel from the enamel-formers being more sharply marked than in dentine.

7th. The method of the development of enamel and the microscopic morphology of the fully-formed tissue precludes the possibility of the existence of enamel-fibers in the sense taught by Drs. Heitzmann, Bödecker, and Abbott.

8th. The demonstrations upon which the foregoing propositions are based, and the evidences furnished by a careful microscopic study of caries of dentine and enamel, lead to the conclusion that the so-called inflammatory theory of decay has grown out of errors of interpretation, and is without foundation in fact.

In conclusion, I may repeat that the deductions to be drawn from my studies of the development and minute anatomy of the teeth in health and disease are in harmony with that practical experience, gained by careful observation, that decreased liability of the teeth to decay must result largely from change in environment; and this is to be effected by cleanliness, local antiseptic treatment by suitable mouth-washes, by giving the teeth a proper amount of work to do, and by such systemic treatment as will decrease the conditions which favor fermentation in the mouth.

DISCUSSION.

President Carr. The discussion of Dr. Williams's paper will now be opened by Professor Frank Abbott, of New York.

Dr. Abbott. Mr. President and Gentlemen: Truth is what we are looking for, no matter whether it comes from Philadelphia,

Berlin, or elsewhere. It is what we have been striving for during the last eight or nine years, and many of us very hard indeed Possibly there may have been considerably more work done in this direction by several other gentlemen present than by the reader of the paper. That our opinions differ widely and emphatically as to the facts in the case, considering our different stand-points, needs not, perhaps ought not, to be doubted. That Dr. Miller, or anyone else, can place under the microscope a section of a carious tooth, whether the caries be artificially produced or otherwise, and make it appear as if it were full of organisms, I have no doubt. But there is one truth that we want to remember, in the first place, which the doctor has kindly referred to, namely,—*that there is organic material in the teeth.* He does admit that there is some twenty-two per cent. of organic matter in the dentine, and that there may, possibly, be a little in the enamel, although that is doubtful. I am glad he has gotten along so far as to admit that it is *not* a solid crystal of phosphate of lime. I have so many times seen, in sections of enamel magnified under the microscope 1000 to 1500 diameters, what certainly seemed to be fibers so clearly demonstrated that the idea of doubting their existence appears almost too ridiculous to talk about. To go back to the question of organization. Bone-tissue, as you know, contains about thirty-three per cent. of organic material (including the matrix into which the lime-salts are deposited, the reticulum of living matter, blood-vessels, etc.). There is an inflammatory condition of bone called osteitis, a disease known to all surgeons, and every man who is familiar with the pathology of bone-tissue understands it. Now, in dentine we have a tissue which presents a little less organic material, it is true, but can anyone sustain the position that because of this slight difference in organic material inflammation cannot occur in it? This is limiting pathology with a degree of certainty quite startling. True, it has no regular circulation, so far as blood-vessels proper are concerned, but that there is a kind of circulation in dentine that we have not yet seen, nor yet understand, I do not doubt for a moment. As an evidence of it we have from the beginning of the deposit of lime-salts in the odontoblasts, through the entire life of the pulps of teeth, a constant accretion of inorganic material in that tissue. A similar process is constantly going on in all the osseous structures of the body. If there is no organic or living matter in the enamel, I would like to know how it is that when the pulp of a tooth is dead the enamel loses its peculiar life-like appearance and looks in every way like dead tissue. How does it change in that manner if there be not something going on in the way of death of the tissue, and how can this occur if it is a solid "secretion" of lime-salts? I was un-

fortunately called out for a moment, and did not hear all that was said in the paper in reference to a recent article of mine upon the subject of the pathology of the enamel of human teeth. There are certain conditions, of course, which predispose teeth to decay, and that their environment has much to do with it there is no question. All that is necessary to say in answer to the reference is that a perfect enamel will withstand an unfavorable environment much longer than an imperfect one. This *fact*, I think, even Dr. Williams will admit.

There is one question in reference to the presence of microorganisms in the deeper portions of caries that has troubled my mind quite considerably, viz: If great numbers of them are left in teeth when they are filled, as must be the case if they are present, as is claimed by some observers, when a reorganization of the disorganized territory of dentine takes place,—a process the results of which are observed by all clinicians,—what becomes of these organisms? Do they enter into and form a part of the reorganized dentine, or do they quietly steal away? They must be dependent upon *outside nourishment*, or it is fair to presume that they would live and thrive under a filling as well as before the filling was introduced. This would seem to "checkmate" the theory that they live upon the organic portion of the tooth, and that they necessarily "secrete" lactic acid.

Mr. President, the opening of a discussion of this kind is a little awkward, particularly after so lengthy a paper as we have heard this afternoon, and one that requires so much thought in its discussion. Perhaps I may ask the privilege of adding a few words later on, or at the close, but I will leave the matter as it is for the time being.

President Carr. We will now have the pleasure of listening to Dr. W. Xavier Sudduth, of Philadelphia.

Dr. Sudduth. Mr. President and Gentlemen: Dr. Abbott has reiterated in your hearing to-night the same sentiment which he has previously published, viz.,—that decay of teeth, while differing slightly from caries of bone, is essentially a similar process. He finds in decay of teeth the analogue of osteitis. He further says that "the idea of doubting the existence of the fibrils is too preposterous to talk about." And again, both Drs. Abbott and Heitzmann say that by the technique which we use to demonstrate microorganisms we destroy the bioplasson bodies. I shall confine myself this evening to these three propositions, and that we may correctly discuss Dr. Abbott's position, I take the liberty of quoting from a paper published by him in the Dental Cosmos, on "Caries of Human Teeth":

"Caries of a living tooth, therefore, is an inflammatory process which, beginning as a chemical process, in turn reduces the tissues of the tooth into embryonic or medullary elements, evidently the same as during the development of the tooth have shared in its formation; and its development and intensity are in direct proportion to the amount of living matter which they contain, as compared with other tissues."*

Your attention is first called to the question, Is decay of the teeth an inflammatory action? I use the term "decay" advisedly, because the process of decay is so unlike that of caries of bone that the same word should not be used to designate the two pathological conditions. It has come to be a generally accepted fact that decay of teeth is a separate and distinct process. As such, it should be so acknowledged.

Caries of bone, as is well known, is an inflammatory action. Decay of teeth, in so far as the crowns are concerned, is a chemical action: the inflammatory concomitant is a secondary element. In caries of bone the disease begins in the organic substance, while in decay of the teeth the inorganic material is first to be affected. In caries of bone the process is vito-chemical. In decay of teeth the order is reversed, and we see a chemico-vital action.

As regards the erosion of the cement and the dentine of the roots of living teeth, when it does occur, I do not think there is any reasonable doubt but that the process is analogous to absorption of bone, and follows the same order. In caries of bone osteoclasts, or giant cells, are an essential element to the carious process. These cells are probably developed from the white blood-corpuscles which have escaped from the capillary vessels. The nourishment of these cells depends upon the close proximity of a vascular supply. In decay of the teeth all these essentials are entirely wanting. Inflammatory *caries* of enamel or dentine is an utter impossibility when considered from the above stand-point.

Let us see if we can substantiate our position.

The initial lesion in inflammation of bone and cement begins in the vascular system. It may arise from traumatic injury or from an extension of disease from previously affected tissue. An example of the first may be found in cases of fracture; of the second, in constitutional syphilis and tuberculosis. At first we notice a hyperemic condition, which is quickly followed by one of congestion, in which there is an exudation of white blood-corpuscles. The exudation may be resorbed and the equilibrium of the circulation restored. On the other hand, the irritant may be so great, and the existing

*See the DENTAL COSMOS, Vol. xxi., April, 1879, page 179.

lesion of such a grave nature, that the character of the exudation may be changed into a purulent condition. In this case the recuperative power of the tissue is entirely overcome and necrosis results. There is an intermediate stage, however, in which the inflammation, once established, is more persistent but less virulent in character. This is designated caries, and a description of this process particularly interests us now, in that we may compare it with decay of the teeth and note the points of dissimilarity.

Dr. Heitzmann holds that erosion is produced by a pathological condition of the fluids of the blood, which liquefies the bone, thus freeing the bone cells, which then coalesce and form the giant cells. He does not satisfactorily account for the presence of giant cells in connection with the absorption of sequestra and other hard tissues in which no living cells exist. Any fluid which has the power of decalcifying bone or teeth, circulating in the vascular system, would have a deleterious action on other parts of the body. I hold that erosion is produced by the osteoclasts at the point of irritation.

Absorption of tissues is a process which is established by nature for the removal of offending particles, or tissues that have performed their life-work, and is therefore physiological, although the process is excited by pathological means. There is set up in the infected part a condition of over-nutrition, caused by the local irritant. The exuded cells tend to form granulation tissue; rapid cell-multiplication occurs, and numerous cells are found that contain more than one nucleus. These are termed giant cells, or osteoclasts, if the body to be removed is bone. Giant cells are found in diseases where great cellular activity exists; for example, in miliary tuberculosis, syphilis, sarcoma, hyperplastic granulation tissue, and in connection with absorption of bone and other bodies which *nature* wishes to remove. They are developed in all such places, unless the exuded cells are destroyed and a purulent condition produced.

Flemming has established beyond dispute that cell division is by nucleus division. In some instances, however, the nucleus divides and the subsequent cell division does not follow, in which case "giant cells" are formed. We do not know positively just why cellular activity occurs. It is highly probable that the cells are stimulated to increased assimilation of cell-pabulum, since we do not always find giant cells in all cases of over-nutrition, but the fact of the appearance of giant cells in absorption of tissue, whether the tissue contains bone cells or not, pretty clearly establishes the fact that giant cells have an identity entirely independent of bone cells. Then, again, the giant cells or osteoclasts present a similar appearance to giant cells found—as before mentioned—in

syphilitic gummata and miliary tubercles. Ziegler uses the terms "osteoclasts," "giant cells," and "resorption cells" as synonymous when speaking of erosion of bone, and says most emphatically that they arise from the exuded blood cells. Exudation *precedes* the formation of giant cells. Giant cells *precede* the decalcification of bone. The bone cells are the last tissues to be liberated in the process of caries; hence they cannot, with any degree of reason, be said to form the resorption cells, giant cells, or osteoclasts.

A description of the process, from Woodhead's "Pathology," will further elucidate the point to which I have reference:

"If the caries is situated in the shaft of a long bone, or in the spongy bone of the alveolar process of the jaw, the trabeculæ will be found dilated and the vascularity of the tissue greatly increased. In a picro-carmine preparation of a malignant epulic growth we see lying on the trabeculæ numerous deeply-stained, rounded cells, which appear to be partially imbedded in a layer of pink tissue. The Haversian canals are much enlarged, and at the same time are very irregular; the irregularity being due to a process of excavation extending from the main cavity down into the bone of the surrounding Haversian system. These cavities, whether shallow or of considerable depth, usually contain a number of small round cells (exuded cells or granulation tissue); but, in addition, when the excavation is rapidly progressing, numerous osteoclasts, which lie in cup-shaped cavities, or depressions, are seen. The cup-shaped depressions appear to be invariably associated with absorption of bone, and are spoken of as Howship's lacunæ. The osteoclasts may be very large, may contain many nuclei, and are, in all respects, similar to the giant cells in myeloid sarcoma. The cells and spaces are much more numerous than they are in normal bone, where they are also associated with a certain amount of absorption."

The roots of temporary teeth are an excellent example of physiological absorption through the agency of the giant cells, but these roots are situated in the jaw, surrounded by highly vascular tissue, which latter is absolutely essential to a carious process. In decay of the crowns of teeth these latter essentials are entirely absent, and the development of osteoclasts or "bioplasson bodies" is an utter impossibility. The ability of the blood-vessels of the pulp to furnish the cellular elements for the production of giant cells is not denied, but if giant cells were produced we should have internal caries. Even granting that the erosion of hard substances is produced by the action of a fluid which exudes from the blood-vessels of the pulp, such erosion would result at the point where the dentine first came in contact with such fluid, so that the latter theory will not apply to decay of the teeth, nor will it hold good in caries

of bone. To the giant cells or osteoclasts is attributed the secretion of a fluid which has the power of liquefying bone,—they themselves sinking into the cavities which they form. It matters not whether the offending tissue be living or dead, if it is soluble. The process is slower when the tissue is dead. The lime-salts are removed in advance of the organic portions in resorption of living bone. Erosion may begin on the outer side and extend inward; it may commence in the medullary cavity and proceed outward; or both may occur at the same time. "A dead piece of bone inserted under the skin of an animal, and examined a few weeks after, will be found interpenetrated with vascular granulations, and the trabeculæ will be beset in many places with giant cells. The whole process is very similar to that of physiological bone-resorption. * * * This process is peculiarly modified when the foreign substance is firmly connected with the surrounding tissue; when it is in fact a necrosed fragment of the tissue itself, such as bone or kidney. In this case the first step is the separation of the living from the dead. Langhaus was the first to describe minutely the process by which larger foreign bodies are absorbed. He pursued the subject experimentally by producing extravasations of blood in various animals. He thus discovered the 'giant cell.' Heidenhain also found them in pieces of elder-pith which he had inserted in the abdominal cavity of animals. Ziegler always met with them in connection with his experiments in placing cover-glasses slightly separated under the skin of a dog. Later experiments with sponge-grafting have demonstrated their presence and active agency in the absorption of pieces of sponge."*

In some instances of absorption of bone, in close proximity to the osteoclasts may be seen osteoblasts building new bone. It is by this after process that bones once formed are enlarged. The osteoblasts on the outer side are adding to the circumference, while the osteoclasts are enlarging the medullary or marrow cavity. The development of the antrum of Highmore may be cited as another example.

No one would think of attributing this action to a pathological condition, yet the absorption is accomplished by the same agency that operates in the removal of bone in caries. It is an undisputed fact that cells have the power of secreting acid fluids to subserve the purposes of nature, and in claiming this function for giant cells we do not go beyond the domain of physiological action. The process of absorption is a purely physiological one, in so far as the removal of the tissue is concerned. The *irritant*, however, that excites the cells to the secretion of the fluid is without doubt pathological; but the action of the cells thus stimulated is physiological. To admit that

* Ziegler's "Pathology."

by the blood-vessels, would be to admit that the process of development depended upon a highly abnormal condition of the fluid of the blood, and that a well known physiological condition is pathological. There can be no doubt that cellular activity may be induced by different agents; but no matter what agent incites the process, the result is always the same, provided the other conditions remain the same.

Nature works through well-known channels to accomplish her ends, and resorption of tissues is one of her many processes. When pathological ends are arrived at, the initial irritant is pathological. In caries of bone it may arise from constitutional disease, such as miliary tuberculosis, in which disease it has been pretty conclusively shown that the irritant is the tubercle bacillus. In caries accompanying syphilis it has not been proven what the initial vice is, but late discoveries point to a micro-organism. Suffice it to say, in general, that in every case when pathological results are obtained cellular activity arises from some irritant having a local expression at the point where the caries is produced,—in which case the caries is the indirect and not the direct result. I cannot look upon it in any other light than that the specific vice of syphilis and tuberculosis acts as the local cause of irritation. It is the old story of circumlocution and removal of a foreign body,—a ball in the flesh or a sequestrum of bone, etc. The presence of the irritant gives rise to a perversion of the equilibrium of the circulation, and the localization of the congestion in the immediate neighborhood of the cause of irritation. This increased flow of nutrition is not in itself sufficient to account for the increased cellular activity, both as regards cell-multiplication and function; for we have congestion many times without the formation of giant cells or the production of acid secretions. No; there is back of all that can be observed some innate principle, which lies in the cells themselves, that leads to these special attributes,—the "ego" in the cell itself, if you please, which turns the local irritant into a cellular stimulant.

Inflammation of dentine may result from traumatic injury, fracture, abrasion, or decay. We will not speak of pericementitis, which may extend to the dentine of the root; it differs in no manner from extension of periostitis, the pericementum being the counterpart of the periosteum.

We will confine ourselves to that portion of the tooth situated above the gums; claiming that the conditions in the decay of that part are entirely different from those in the root. In caries of bone the initial lesion is an inflammatory process, in which inflammation precedes erosion of the osseous structure. Now, on the

other hand, in decay of the teeth the order is reversed, and erosion antedates the subsequent inflammation. As we have seen, caries of bone depends upon a highly organic and vascular condition of the surrounding tissue; in fact, a typical inflammation is always dependent upon such conditions. Now, the inflammatory process seen in connection with dentine is of a very low grade, because of the small amount of organic tissue found in dentine. Mind, I do not speak of inflammation of the pulp, but of the dentine itself. As regards inflammation of enamel, *I have nothing to say, since to my knowledge none exists.* And right here comes in a marked difference between those who look upon decay as a vito-chemical action and those who hold that the process is just the reverse, viz., chemico-vital. Those who hold to the inflammatory view of decay claim that there is a direct calcification of the organic or cellular tissues in the development of the dentine and enamel. I think that I have offered conclusive argument to the contrary in the pages of the DENTAL COSMOS, and so will not inflict them upon you here, but refer you to the November and December numbers for 1884.

That Drs. Heitzmann and Abbott hold the theory that inflammatory processes depend upon a large per cent. of organic tissue is evidenced by the fact that they have tried to formulate a theory of development that will fit such preconceived ideas of decay. They have entered through the wrong door. They should have built their teeth first, and afterwards torn them down.

A man once started on a wrong theory naturally seeks to bend every appearance in support of the position he has taken and prove its correctness. Thus it is that so many erroneous conclusions are reached by those who reason from preconceived ideas. Dr. Abbott claims that he has seen a *fine* net-work of reticular substance left after decalcifying enamel. Now, I have tried faithfully to preserve and demonstrate this "reticulum." I have taken teeth fresh from the mouth and put them directly into Müller's fluid, handling them with as much care as I would nerve-tissues. After several days I ground sections, not allowing the tooth to dry. After grinding I placed them in alcohol to remove the acid, and then stained them by the best technique known. I failed to discover any "reticulum." Again, I have taken sections thus prepared and decalcified them under a cover-glass on a slide on the stage of a microscope, carefully watching the process from time to time. *Results negative.* The fluid used was one-half of one per cent. solution chromic acid.

Again, to avoid all possibility of error in technique, I imbedded sections of freshly-ground teeth in celloidin, and decalcified them in a one-half of one per cent. solution of chromic acid, stained and afterwards examined them with a Zeiss one-twelfth hom. oil im. lens, with-

out being able to demonstrate any organic tissue. By the last-named process it was not possible for the reticulum to disappear through faulty technique. The celloidin, acting as a perfect imbedding mass, was not affected by the acid in the least degree; nor did it hinder in the process of staining, for it is well known that it is more permeable to stains than tissue itself. Further, previous to decalcifying the section, I placed it on a slide, and drew on the reverse side of the slide, with a writing-diamond, the outline of the section. This I used to compare the former outline of the enamel with, by placing the section on it to study. I could thus tell exactly where the reticulum should appear. I did not allow the enamel to be entirely eroded by the acid. The line of demarkation where the decalcifying process stopped was well defined, and no appearance of organized or reticular tissue was to be seen between that portion of the enamel and the line drawn on the back of the slide which marked the periphery of the enamel before decalcification. On the strength of these and numerous other experiments, made in decalcifying enamel, both in mature and developing enamel, I deny the existence of such a reticular substance.

There is another point of dissimilarity between caries of bone and decay of teeth,—viz., the two processes do not give the same reaction when sections of each are stained with picro-carmine. This fact is mentioned by Dr. Miller, who says that "any one who has given time to the study of inflammation, particularly of bone or cartilage, will at once be impressed with the fact that there is not the slightest similarity between it and caries dentium. Furthermore, the action of different coloring matters upon carious dentine furnishes information of considerable interest; for example, picro-carmine colors the simply decalcified, otherwise unchanged, basis-substance pink or red, while the distended tubules or round or oval cavities, filled with débris and fungi, are stained yellow. This reaction is in marked contrast to that of pulp-tissue, periodontium, bone cartilage, etc." I have often noticed this point of difference, and can fully agree with Dr. Miller. Here again comes in the need of broad experience in the action of the different stains in the various pathological processes.

Differential diagnosis by means of stains is a point well-known to those who are conversant with the different chemical reactions of tissues. It is by reason of these variations that we are able to obtain different colors from the same stain in a section which contains more than one tissue. In accordance with this knowledge we can, with a considerable degree of certainty, use stains as aids in diagnosis.

The result of inflammation in bone is aggressive, and is very apt to be followed by loss of bone-tissue. Inflammation of dentine is a

defensive process, and through its action barriers are thrown out to stop or hinder the advance of disease. This is well known to every observing dentist, and I need not stop to enter into its discussion except to mention the translucent zone and the development of secondary dentine. In my opinion, enamel is nothing more nor less than a coat of mail supplied by nature to protect the dentine, by furnishing a hard surface, and to answer the process of mastication. The *presence* of any considerable amount of organic material that would entitle it to the dignity of accrediting to it an inflammatory action would be just so much against the proper fulfillment of its office. Nature, when left to herself, develops a beautiful and symmetrical object, perfectly capable of subserving her purposes. But, then, you say, why does not enamel resist decay? You might with equal propriety ask why do we sicken and die? Simply because we have transgressed nature's laws. God in his wisdom created man physically perfect. Man in his weakness has perverted this nature, and disease has followed as a natural consequence of his transgressions. The nearer we can put ourselves in harmony with nature the better able shall we be to interpret her creations. If we enter upon our investigations without preconceived ideas, with open and receptive minds, we shall find that many of the processes which we are trying to make out as intricate and obscure will be plain and easy to understand.

The normal condition of the fluids of the mouth is neutral or alkaline, and any deviation from this state is pathological. Enamel was not intended to resist pathological conditions. It was created to fulfill the requirements of nature when the surroundings are normal. Decay of enamel is the result of the melting down of the lime-salts that constitute it, by an acid condition of the saliva. This pathological condition of the secretions of the mouth frequently accompanies some form of general disease, as diabetes, gout, or gastro-intestinal disorders. It is also often observed in parturition, which, by reason of our present way of living, has come to be reckoned among pathological conditions. Morning sickness is an almost constant accompaniment of parturition, and there is seldom any attempt made to neutralize the acid fluids of the stomach, which are so frequently found in the mouth at such times. Local diseases of the gums or mucous membrane of the mouth often give rise to acidity of the secretions. Pathological conditions of the glands that empty into the mouth, and acid foods and medicines, without doubt play an important rôle in decay. I think that sea-sickness has a great deal to do with the rapid destruction of the teeth of foreigners (servant girls) which is noticed soon after their arrival in this country, rather than the oft-repeated explanation of change in habits and diet. The

fluids of the stomach are normally acid, but are *decidedly pathological*, when brought into contact with the teeth for any great length of time. I have never seen any attempt at cleanliness evinced by steerage passengers after paying their debts to Neptune, and I think that all will admit that the use of the tooth-brush is an art that is acquired after their arrival in this country, if learned at all. The idea that all foreigners have good teeth is fallacious. I saw more toothless women in Europe last summer than I ever saw in America in the same length of time. The latter appearance, however, may be partially accounted for in the fact that the masses in America can better afford to have lost teeth replaced, and do so.

Above all the before-mentioned conditions which favor decay, I consider the most active agent to be an acid developed at the seat of decay by acid fermentation. Dr. Miller, of Berlin, has very conclusively shown that this fermentation is produced by micro-organisms. He has isolated twenty-two separate forms, and has cultivated them sufficiently to classify them and note their principal reactions, whether acid or otherwise. He says, "Sixteen produce an acid reaction in a solution of beef extract, pepton, and sugar, and for the rest the results were not satisfactory; sometimes the reaction being acid, at other times neutral or alkaline, depending upon the material used for their culture. Some which have an acid reaction in a fermentable solution give rise to an alkaline reaction in non-fermentable solutions." According to Dr. Miller, "decalcification is produced chiefly by acids resulting from the action of these organisms upon certain of the carbohydrates in the human mouth, while the peptonization is produced either by the direct action of the protoplasm of the organisms upon the decalcified dentine or by a ferment which they produce." Three years ago I gave considerable time to the study of micro-organisms found in cavities of decay, staining them by the best-known methods at that time. I succeeded in satisfying myself that no micro-organisms ever penetrated the dentinal tubuli beyond the point of decalcification. The dentinal tubuli are impervious to the entrance of these organisms while they are in a healthy state. As a contribution to this part of dental discussion, I presented these slides, with others, at a lantern exhibit given before the Illinois State Dental Society, and stated my convictions on the subject at that time. These were ground sections. I have since cut sections of the decalcified mass found in cavities, and demonstrated several of the micro-organisms figured by Dr. Miller. My sections also fully confirm his statements regarding their presence in the tubuli of this portion of decay. I can fully substantiate what Dr. Miller says, viz., that "micro-organisms can, and often do, not only distend separate tubules, but push whole tubuli aside, and these foci are the points figured by Dr. Abbott as 'bioplasson bodies.'"

For the demonstration of micro-organisms of decay we take as large a portion of the soft decalcified mass found in the cavities of decay as we can detach by aid of a broad, hoe-shaped, or other suitable excavator, and place it in alcohol. After the water has thus been removed we imbed in mucilage or celloidin upon cork, and cut sections with a microtome or razor. These can be cut quite thin, as they are completely decalcified *by the acids of the mouth.* After cutting sections, place them in an aqueous solution of any aniline dye, preferably fuchsine. After staining, place in absolute alcohol and remove excess of stain; then dehydrate in oil of cloves or cedar, and mount in balsam. The only acids that come in contact with the specimens are those found in the cavity of decay. The methods necessary for the examination of these micro-organisms are about the simplest of any in use in the study of mycology; and their demonstration the easiest of all the forms we are called upon to study. For some forms of bacteria, however, the methods are more difficult, and their demonstration has taxed the knowledge of our best chemists. Among the most difficult to study have been the tubercle bacillus and the bacillus of lepra. Spores have always been extremely difficult of demonstration, but are now pretty generally understood, thanks to the untiring efforts of such men as Koch and Hueppe.

The bacillus lepra, spores, and tubercle bacilli can be put into a twenty-five per cent. solution of nitric acid, then through two separate baths of absolute alcohol, and yet hold their stains,—provided the staining fluid which contains the sputum or spores is brought to a boil or left for twenty-four hours. It is the knowledge of these properties of bacteria in general upon which we base our assertions that certain foci indicate micro-organisms. But it is not essential that we depend even upon this knowledge. We can take portions of the suspected material, while it is fresh, and cultivate it upon gelatine or other suitable media. After cultivating it through several generations, until we have produced a pure culture, we can prepare a cover-glass, stain and study the isolated organisms. But even this is not sufficient to establish the fact of their being the active agents in decay of teeth. The demonstration of the persistent occurrence of these organisms is of very little import unless the investigator cultivates them and produces decay by their action upon teeth placed in the culture solution. Dr. Miller has done this by the action of some of these organisms on dentine, which I cannot distinguish from decay produced in the mouth. And, further, he has by difficult chemical analyses proven that the special acid concerned in decay is lactic. In this latter direction he has gone farther than most mycologists. Not only is it necessary to produce decay by the fungi, but the destructive acid must also be determined.

I have studied nearly all the pathogenic bacteria in tissues, and have *cultivated* quite a number of the non-pathogenic, together with a few pathogenic forms, and so feel capable of judging the character of the work done by Dr. Miller. Very few are aware of the immense amount of labor involved in the study of micro-organisms. My reason for quoting Dr. Miller so extensively on the point under discussion is that I have not sufficiently studied the special fungi concerned in decay to offer an opinion unsupported by corroborative testimony. I believe in the reliability of Dr. Miller as a scientific investigator, and my belief is based upon the scientific manner in which he has done his work, and the uniform willingness he has shown in allowing others to see the slides and cultures from which he has drawn his conclusions. The fact that he is quoted by such an author as Ziegler shows that he is regarded by his colleagues as an original and trustworthy investigator. Dr. T. Mitchell Prudden met Dr. Miller last summer in the laboratory of Dr. Koch, and speaks very highly of his work. I have in my possession a culture of a comma bacillus which was discovered in the mouth by Dr. Miller, and which has received the name of Miller's comma. The standing of a scientific man is in proportion to the honesty and industry with which he works, and I think that I have now cited points enough to prove that Dr. Miller may be safely quoted as reliable authority on the subject of decay.

In conclusion, it may not be inappropriate to speak very briefly of the position of dentistry in regard to scientific research. I fear that we do not as a body realize the importance of putting all our statements on a scientific basis, and submitting them in a scientific manner. We are too apt to base our theories upon information about different phenomena, instead of building them securely upon active knowledge of visible results. Gentlemen, this may have done in the past, but it will not do now. Scientific investigation is constantly changing the points of view from which we have been in the habit of regarding various pathological conditions; it keeps on presenting new suggestions and new discoveries. To meet this advancement it is required that we subject all our theories to the crucial test of careful experiment. Nor is this all: we must be able to *show* the results from which we draw our conclusions.

The day is passed when simple assertions or drawings of other men's work will suffice to establish a scientific point, and our profession will never be the power it might be until as a body we recognize the true value of the experimental investigation of actual facts wherever these are accessible to study, and demand that all pathological questions connected with our work shall be pursued from a scientific stand-point, and the visible results presented for investiga-

tion. If we would be forceful men in the domain of science we must present facts for authority, not authority for facts; we must freely give the methods by which our knowledge is augmented, and allow others to study and weigh our work. Above all must we be prepared to modify our views or abandon them if errors should be discovered and plainly pointed out.

Let us take as capital examples of the true scientific spirit the researches of Dr. Koch and his school. The preparations upon which their inferences are based have been freely shown to others, and they have done their utmost to extend the boundaries of medical science by publicly revealing new facts as they have gathered them from various experiments. Compare the attitude of these men with that of Dr. Ferran. He rose like a meteor and sunk as rapidly, not because he was incapable of performing the experiments in which he was engaged,—for he had studied in some of the best laboratories in France and Germany,—but simply because his methods did not bear the stamp of true scientific investigation. He refused to demonstrate the facts upon which his theory was based, and consequently scientific opinion was against him.

These thoughts are offered as a mere outline of the direction which conscientious inquiry in dental pathology is now taking. The attendance here this evening shows the interest that is being awakened in scientific dentistry, and I trust that it will be the means of exciting an increased desire for scientific information. Many difficult problems are now awaiting the patient student. He who would solve them must first learn his a, b, c's in the field as taught in normal histology; his x, y, z's in general pathology. Then, having just learned the use of the tools which will constitute him a novitiate in science, he may pass into the field of special pathology, including mycology, where he will find at least a partial key to the solution of some pathological problems. Until he has done this no man is entitled to high rank as a scientist. Let us, then, as a dental profession aspire to true scientific attainments, and prove ourselves worthy of the title of a scientific profession.

President Carr. Gentlemen, we will now have the pleasure of listening to Professor Carl Heitzmann, of this city.

Dr. Heitzmann. Mr. President and Gentlemen: There was a young man in the far West who did farm work until he had grown to be twenty-four or twenty-five years of age. Then he made up his mind to learn to read and write, and he began to learn the a, b, c's. His name was Bob. He found another young man who could read and write, and engaged him to teach him his a, b, c's.

The teacher's name was John, and when Bob, who was a very intelligent fellow, reached the letter k he suddenly jumped up and ran out of the door. John shouted after him, "Bob, where are you going?" Bob turned to his teacher and boastfully said, "Now I am going to teach the a, b, c's, John." The gentlemen who have attempted to talk about the history of the development of the teeth this evening have only reached the letter k of the a, b, c's, and that includes myself, because in my twenty-five years' work on the teeth I have not yet reached the letter z in the alphabet of their histology. Dr. Williams in his paper does me the honor of repeatedly quoting me, and especially alludes to things that I am assumed to say regarding the history of development in my book. But there I say very little, for all that is published in my book about the teeth emanated from Dr. Bödecker and Dr. Abbott. The little I say of the history of their development is that we don't know anything about it. Whether this is worth quoting or not I don't know. I feel thankful to Dr. Williams that he does quote me, but I don't deserve it. The few points that I have looked into in connection with this subject are just those which Dr Williams ignores entirely in his paper. Dr. Williams has said some things of great wisdom indeed. For instance, one of the important points he brought forward was that the bone-formers will not produce dentine, and the dentine-formers will not produce bone. That is just as good as to say that a white man will not produce a black child and a negro will not produce a white child. I ask what is gained by such speculations on vital forces? Of course there will be a few who still believe that there may be an exception to the rule that a black man cannot produce a white child.

Dr. Williams's explanation of teeth being found in the ovarian cyst is that remnants of previous epithelia, which once helped to form teeth, were transported into the ovary, there developing teeth. Then he admits another theory, that perhaps the epiblast which produces the tooth originally might have caused some mischief in the ovary, giving rise to teeth in the ovarian cyst. But, gentlemen, a white man cannot beget a black child. How is it possible that in the ovary not only teeth are present, but there are hairs, bone, cartilage, and even muscles? We know a theory that will explain it,—viz., that in the earliest period of the development of the embryo there was developing another one, inclosed in the ovary, and parts of the inclosed embryo developing in the ovary were left and grew there, just the same as if present in the womb.

Quite recently I was asked to see a tumor which was removed from the abdominal cavity of a living woman by Dr. Mundé, replacing one of the ovaries. I cut into and found it hollow. I examined

it under the microscope, and, much to my surprise, I found this to be the chorion, with its villosities, of a six-weeks embryo. This fact gives a positive hint as to the development of teeth in the ovary. But why should we speculate and argue about the presence of teeth in the ovaries of women? If we only knew the history of their development in the mouths of men we were a very happy people indeed; but we do not. In the last twenty-five years I have seen plenty of specimens,—more, perhaps, than any other person present,—but notwithstanding such a large experience I cannot say that I am ready to settle this matter positively.

Dr. Williams says it is mere speculation to maintain that the dentine is kindred to bone-tissue, because in the latter there are globular territories which he thinks are lacking in dentine. I will ask Dr. Williams if he has ever seen the so-called interglobular spaces of Czermak, by no means a pathological condition? They often occur some distance below the enamel traversed by canaliculi. I ask Dr. Williams whether he has ever seen the bay-like excavations of dentine of temporary teeth, invariably present in the process of dissolution, preceding the falling of such teeth? I ask Dr. Williams if he has seen specimens of inflammation of the dentine, where bay-like or globular excavations occur, traversed first by dentinal canaliculi, and later broken up into medullary corpuscles? Still he asks, Is there any such thing as a globular structure of the dentine? I was prepared for almost any attack, gentlemen, but not for that; because I had supposed there was not the least doubt that the dentine is globular in its structure, the same as bone. That, however, dentine is not bone, and bone is not dentine, is one of those ingenuous assertions of Dr. Williams which can scarcely be discussed.

Let us inquire about the history of the development of the dentine. I will draw here the boundary line of the dentine towards the pulp, and close to the dentine the odontoblasts, which send offshoots into the dentinal canaliculi; two or three dentinal fibers, sometimes only one. Can Dr. Williams explain how, by the calcification of these odontoblasts, the globular basis-substance of dentine will arise? For it seems not only antique, but almost antediluvian, to speak of a secretion as causing the formation of the basis-substance. How can he explain the fact that in the recently-formed dentine there are fields of basis-substance much narrower than the original odontoblasts? I have studied this question over and over again, and have come to the conclusion that the odontoblasts cannot be direct dentine-formers. To explain the formation of the globular character we must take another ground,—namely, that the odontoblasts are not permanent, stable forms at all. They are forms which arise and are visible during the period of rest of the pulp-tissue. As soon as den-

tine is about to form the odontoblasts break down or split up into medullary corpuscles; and we often see directly the globular shape of groups of such corpuscles. Between the medullary corpuscles the dentinal fibers are formed, although they were originally in connection with the odontoblasts. The odontoblasts are not direct formers of the dentine, but the medullary corpuscles are, just the same as in any other variety of tissue. The odontoblasts are materially the same formations in relation to future dentine as the osteoblasts in forming bone-tissue.

The second point which Dr. Williams alluded to was the formation of the enamel. I purposely left his sketch on the blackboard, because I am sorry for it. The greatest achievement of scientific American dentistry is the knowledge of the minute anatomy of the teeth. Up to the time of the studies of Bödecker and Abbott the histology or minute anatomy of the teeth was about at the level at which the Philadelphia gentlemen seem to be to-day. Their histology is a little yellowish with age,—a little musty. We have learned something from the careful researches of Dr. Bödecker, and it does not make any difference that they were made in my laboratory. Dr. Bödecker was the first to find out that the enamel and the dentine are both living tissues. Then Dr. Williams comes with the assertion that about ninety-seven per cent. of lime-salts are present in the enamel, and that the rest is organic material. What is the chemist doing when he goes to measure or weigh his lime-salts? Surely destroying the living matter first, either by fire or by some reagent. To positively state how much organic matter the enamel contains is impossible. That it is very little I admit, but that there is some living matter in the enamel is quite certain. A celebrated worker in dental histology was here three years ago, Prof. Wedl, my old teacher. He visited my laboratory, and we discussed this enamel question. He was then sixty-nine years of age, somewhat older than our friend Dr. Williams. I asked Professor Wedl to please tell me his opinion about the enamel-fibers which Dr. Bödecker has discovered and described. He said in answer: "There is not the least question in my mind that the enamel-prisms are separated from each other by narrow interstices." Said I to him, "Who tells you that? Where have you read that?" Because we had looked over the whole literature of the subject, including his own book, and every author gives that unfortunate picture that Dr. Williams gives, illustrating that the enamel-prisms are in close contact with one another. I am very much afraid that Dr. Williams is looking at the enamel from a stand-point that has been abandoned for at least ten years. An authority, whom Dr. Williams will scarcely doubt, is Dr. Tomes, of London. He was here last year, and was shown enamel

in Dr. Bödecker's house. He drew the fibers between the rods of the enamel just as we see them. Take a temporary tooth and grind it, and you can easily see the enamel-fibers. Or take a section of pigmented enamel, and you will see the fibers, because in the pigmented enamel the difference in color is greater than it is in ordinary white enamel; the interstices are wider and the fibers positively plainer.

Now we come to the question of the development of enamel. It is the most difficult question of all. Dr. Williams justly alludes to the presence of ameloblasts, nucleated bodies, and he admits that not infrequently we see in a section long fibers which go to and from the already formed enamel. He gives a beautiful explanation of this fact. He says, if you put your fingers into syrup and draw them out, you will have a thread of syrup from each finger. But that is Philadelphia syrup. I do not like it. Has Dr. Williams forgotten that we harden our specimens first in chromic acid? There is nothing of the consistence of syrup any more. When we make the sections the fibers are really present, not only when drawn out by the razor, but also *in situ* between the ameloblasts.

Now, gentlemen, we come to the point that, according to Dr. Williams, there is no similarity between the development of the enamel and that of dentine. He asserts that the ameloblasts directly form the enamel-rods. One point, as I said, is very superficially touched upon in my book; and although Dr. Williams does me the honor of repeatedly quoting me in his paper, he gives no explanation of what is to be seen. After the sixth week of embryonal life a prolongation of the stratified epithelium of the oral cavity is formed, a solid peg, and which is admitted to be the future enamel; whereas from the embryonal connective-tissue is formed a button-like projection, the papilla, viz., the future dentine. The epithelial peg is originally solid. Does it remain solid? No; in the third, fourth, or fifth month of the embryo, before any dentine begins to grow, you distinctly see that the epithelial peg becomes hollowed out, and in its interior begins to show a myxomatous tissue, consisting of a beautiful reticulum, long since known. Whence is that myxomatous tissue? Nobody has maintained that myxomatous tissue is epithelial tissue, but it is admitted to be a variety of connective-tissue. Nobody will maintain that migrating corpuscles have crept through the epithelium in order to produce myxomatous tissue; therefore we must argue that the latter has developed from the epithelia. But now comes a learned man and says that epithelium will never produce connective-tissue, for these are tissues of their own, independent from each other. Such a man overlooks one thing, however, viz., that the whole nervous system of the

embryo is developed from the epiblast, which is distinctly epithelial. The original brain and spinal cord is a prolongation of the epiblast. From that arises the nerve-tissue, which is freely mixed with connective-tissue and freely vascularized. I deny that there is no transition from epithelial to connective-tissue and vice versa, although I concede that nobody else would admit such a liberal view, contrary to all that the books teach.

Do not forget the instructive story of the Austrian peasant, who had a vineyard and raised sour wine year after year. One day an expert in wine-making came there and said to him, "My dear fellow, why don't you take into consideration the new methods of cultivation? Why don't you import some seedlings and get a better wine? Your soil is splendid, and you could have a brilliant wine if you would just adopt the improved methods of culture." And the conservative old peasant replied, "My father and my grandfather did as I do, and raised wine without these new methods. Why should I change what they found good enough?" And of course the man still raises sour wine. A great many histologists are in the same situation. They have learned the old doctrines and stick to them. Nature does not narrow herself to any one idea of a histologist. From this point of view, gentlemen, all the previous assertions as to the formation of the enamel-prisms directly from the ameloblasts must fall to the ground. Before the ameloblasts are formed there are present medullary corpuscles; and before enamel-rods do form the ameloblasts are again broken up into medullary corpuscles. Then the same rule holds good in respect to the history of development of the enamel that applies to the history of development of the dentine. In one case it goes toward the center, centripetally, and in the other toward the periphery, centrifugally. The ameloblasts are merely provisional forms, similar in aspect to epithelia, the same as are the odontoblasts and osteoblasts.

That already formed tissues of a certain type do change their character by falling back into the medullary or embryonal condition, afterward giving rise to an entirely new tissue, is a well established fact in histology. Look into the history of development of bone. In the embryo there is no bone, but cartilage only; for the first tissue that forms from the medullary tissue is cartilage. This, before being transformed into bone, falls back into its medullary condition, and the medullary tissue at last forms bone. If you break a bone purposely, in order to find out how the fracture heals, the same thing will happen. What we call provisional callus is nothing but cartilage. The medullary or inflammatory corpuscles in this instance first form cartilage,—not directly bone,—but the cartilage breaks down into medullary tissue afterwards, and at last arises bone-tissue, the permanent callus.

Now, gentlemen, comes the question of caries. Dr. Williams takes three victims, Dr. Abbott, Dr. Bödecker, and myself, and tries to twist our heads off and put them in his pocket. Dr. Bödecker is to follow me, but I am very much alive yet to defend myself and kick against Dr. Williams. These three men, he says, have made up a theory regarding the cause of caries, and they give certain figures, just because it suits their theory of the development, formation, and anatomy of dentine and enamel. He speaks with great emphasis of what a horrid thing such a procedure is. One thing, however, Dr. Williams has overlooked,—that Dr. Abbott has not insisted upon the fact that caries is primarily an inflammatory action. He says in a foot-note first that a dead tooth decays,—is destroyed in a chemical way,—meaning by an acid, of course. Dr. Abbott says that in living teeth the first impulse to decay is an acid that works upon the enamel, and from that impulse comes the process of disintegration. He speaks several times of micro-organisms in his paper. He simply claims that in living dentine and enamel there is a reaction upon the irritation, and that you can see, before the dentine and enamel decay, a zone containing medullary corpuscles. He claims that there is a reaction upon the injury done by decay. Of course, to say that caries is primarily an inflammatory process would be a mistaken ground; and nobody is willing to claim that there was inflammation in an entirely dead tooth. Now, these gentlemen from Philadelphia almost kneel down before the great god Miller and worship him; forgetting that all that was said long before Miller by Leber and Rottenstein. There is not the least question to my mind that the enlargement of the tubules is not caused by the growth of leptothrix and micrococci alone; but there is a decalcification before decay, and decaying material is just crowded with such micro-organisms; and upon the irritation of this decaying material sets in an inflammatory reaction in a secondary way. You can see in Miller's specimens that the growth of micro-organisms does not go so far as the decalcification goes. Therefore, there is first decalcification; then a growth of leptothrix. Nevertheless, they say that all decay depends upon the leptothrix. Behind all this decalcified zone you invariably see, in specimens taken from live teeth of man, and preserved in a chromic-acid solution, inflammatory changes. Such specimens of caries are to be seen in my laboratory in any number. Dr. Sudduth says God made man perfect, and man makes himself imperfect. I doubt that very much, for nobody is born perfect. Neither is life an enjoyment, but rather misery and hard work. As Dr. Sudduth says, a scientist must show what he affirms. It is not enough that he makes drawings only; he must prove them by specimens. I have such specimens; and my laboratory is, year after year, crowded by students,

including many dentists, who come to me to see these things, and I believe that all of them leave satisfied. Does Dr. Sudduth doubt that what we represent is correctly done from nature? Most of the drawings I made myself, because I am an old draughtsman, and I think everybody has admitted that I can draw. These illustrations are made with the utmost care as to details. We do not take it easy in our laboratory. It is very hard work indeed. Will Dr. Sudduth do me the favor to come and look at these details? He says he cannot see them; and that I believe, word by word. He cannot see, I am satisfied.

Dr. Williams. Mr. President and Gentlemen: Dr. Heitzmann's remarks remind me of the reply which a talented young Congressman, a fellow-townsman of yours, made in answer to certain critical remarks of Mr. Blaine,—that he had yet to learn that it was a crime to be a young man. I have the highest respect for the wisdom and experience which comes with years, but I submit that the time is past when the value of a man's scientific opinions is to be based upon the number of summers and winters which have passed over his head. I think we may all appreciate the extremities to which the professed champion of scientific truth is driven, when he finds it necessary to resort to the recital of funny stories in order to distract the attention of his audience from the weakness of his position. In a different sense from that intended by Dr. Heitzmann I accept the rebuke; it is well for a young man not to know too much. The obstinate pride of opinion which sometimes leads men of years to turn away from the new truth which is constantly coming into the world has doubtless often grown out of the puffed-up, conceited wisdom of earlier years. Therefore, if a young man does not place too high an estimate upon his present acquirements, he is likely to learn something as he grows older. Besides, I believe with Josh Billings that "it is better not to know so much than to know so many things that ain't so."

There is another and a better reason why I will not occupy your time in replying to the very few points of significance in Dr. Heitzmann's remarks. We have with us to-night a gentleman who is older than I am, who is older than Dr. Heitzmann, and who has spent his entire life in the study of the development and histology of the teeth. If this gentleman, for whose scientific attainments I have the highest respect, shall confirm the position which I have taken, it will at least be a complete answer to the silly story of the country youth who desired to pose as a teacher before having himself learned the alphabet. The attitude which Dr. Heitzmann has assumed in this discussion forces me to mention a little incident which

occurred several months ago, and which I should not feel like mentioning but for his misrepresentations of the position which I have taken He correctly says that I spent some time in his laboratory as a student, but his statement that I was in agreement with all of his vague theorizing is quite unwarranted. I went there, not to contradict his statements, but in the hope of gaining some new light on the subjects in which I was most deeply interested at that time. But Dr. Heitzmann has evidently forgotten that several months after I left his laboratory I returned and exhibited some specimens to him, in the presence of Drs. Atkinson and Bödecker, in which the dentinal fibrillæ were shown to be offshoots of the odontoblasts. At that time Dr. Heitzmann frankly admitted that the point was clearly demonstrated, and that he had been mistaken in his teaching that these fibers originated in the pulp reticulum and passed between the odontoblasts.

Dr. Heitzmann. Will Dr. Williams remember that I drew offshoots of the odontoblasts on the blackboard,—not only one, but two or three?

Dr. Williams. Do you mean before I exhibited the specimens to which I have just referred?

Dr. Heitzmann. Yes.

Dr. Williams. I remember that some time before this you attempted to reconcile the observations of all our recognized teachers of this subject with your own views. Are there any drawings in your book showing the dentinal fibrillæ as offshoots of the odontoblasts?

Dr. Heitzmann. Several are drawn there between the rows.

Dr. Williams. No such appearance is shown in any of the engravings in your book, and I have never seen any of your drawings remotely resembling the sketch which I have made on the blackboard.

President Carr. Gentlemen, the discussion of this subject will now be continued by Dr. C. F. W. Bödecker, of this city.

Dr. Bödecker. Mr. President and Gentlemen: It is well known, ever since the publication of Franz Boll, of Bonn, that whenever a fiber develops from a protoplasmic body it is always from its periphery, and never in any instance from its center. Fibers may appear as though coming from the end of a protoplasmic body, but they are peripheral formations sometimes joining at a point in one of the ends of these corpuscles, either the front or the back. This may have led to the belief that the fibers extending from protoplasmic bodies called odontoblasts are developed from their center. I have

seen many specimens of odontoblasts and other tissues, but I have never in a single instance been able to observe that a fiber from the point of the odontoblast has been traced through the center, nor do I believe Dr. Williams has. Dr. Williams and Dr. Sudduth both claim that there are no enamel-fibers present in any preparation of human enamel. If these gentlemen will take the trouble to split a freshly-extracted tooth and throw it into a solution of osmic acid which will stain the living protoplasm and nerve-fibers, they will find that it has stained the enamel-fibers as well as the dentine-fibers in their proper situation. The history of the development also shows this. The fibers are quite plainly visible in every embryonic specimen of enamel. In fact, it was such specimens that led me to the study of enamel-fibers; although I have to admit that the enamel-fibers in adult teeth, when stained with other reagents than osmic acid, do not appear very distinctly, for when studying enamel with Dr. Heitzmann, on calling his attention to the fibers in a ground section of enamel, very slightly stained with an ammoniacal solution of carmine, he laughed and pronounced it to be dirt from the process of grinding; but after studying another specimen, stained with chloride of gold, he fully admitted the presence of enamel-fibers. Dr. L. Waldstein—a gentleman who has been an histologist and was the assistant of Professor Arnold, of Heidelberg, for years—saw some preparations which I had arranged for the microscope, and I asked him to tell me whether he was able to observe any fibers within the enamel. I informed him that the specimens were prepared and stained in the following manner: The teeth, immediately after extraction, were split and immersed in a one per cent. solution of hyperosmic acid for twenty-four hours, and then put in absolute alcohol for two or three days, ground thin upon a corundum-wheel, and mounted in the usual manner. After a careful examination, Dr. Waldstein pronounced the dark fibers lying between the enamel-rods to be protoplasmic formations. Therefore, unless there is something mysterious about the osmic acid, or the lenses I employed (which were made by Zeiss) are unreliable, I must hold to the assertion that there are enamel-fibers between the calcified rods of enamel in the human subject.

I have examined many specimens of ground teeth the peripheries of which were slightly attacked by caries. In one specimen I noticed places where a little of the enamel was rubbed away,—hardly perceptible to the naked eye. In the fissures of the tooth there was very slight decay. I observed at the boundary between the dentine and enamel a reaction in the enamel-fibers which made them appear much swollen at a point corresponding to the enamel that had been rubbed away at the periphery; also, at a point corre-

sponding to the fissure which was slightly decayed. Some of the fibers thus affected could be followed for quite a distance, and they appeared the thickest or most swollen towards the boundary of the enamel and dentine. Gentlemen, can you imagine that bacteria would have crawled in at the periphery of the enamel along the fiber without leaving a trace or track, and only produce a reaction near the dentine; or, to use an expression of Dr. Abbott's, without "using their acid bottle" in the beginning? Evidently they did not use it at the beginning, because I observed no enlargement of the interstices or reaction of the enamel-fibers at the periphery, but only between the boundary of the enamel and dentine, and corresponding in width to the place of injury. Of course, it is quite evident from this that there must be living matter in the enamel; for, if there were no living fibers in the enamel, how could such a reaction occur? Dr. Sudduth acknowledges that the enamel is absolutely closed at the periphery, and that nothing can get through. If there is no living matter there, what produces that reaction? I have never observed it in specimens with perfectly sound enamel around the periphery of a tooth. I have shown these specimens to Dr. Heitzmann and Dr. Abbott, and anyone who chooses to come to my house or Dr. Heitzmann's laboratory can see them.

With regard to the elucidation of the question of necrosis, spoken of by Dr. Sudduth, I have to mention that one of my first attempts to study special subjects in Dr. Heitzmann's laboratory was the observation of necrosis. Both Dr. Heitzmann and myself were much surprised at the slight difference, under the microscope, of normal and necrosed specimens of bone. It is all very well for gentlemen to say that necrosis of bone is an entirely different process from caries of teeth, and in a certain measure that is so; but I do not believe that caries can be so very widely distinguished from necrosis. I do not, therefore, object to the term caries in comparison with caries of bone, although it must be acknowledged that bacteria must necessarily exert an immense influence upon caries of the teeth, because they are present wherever putrefaction is going on. May the patient be ever so healthy, they are there; and the conditions are nowhere in the body so favorable, probably, to the production of caries as in the mouth. But, at the same time, I cannot believe that caries is the immediate and only result of these organisms, and that the reaction of the living protoplasm which is visible during caries should have no influence in this process. In specimens of caries of dentine which I showed to Dr. Waldstein,—who is a perfectly impartial observer, and who has had much experience in the study of bacteria; has written several essays on that subject, and is frequently quoted in medical literature,—although he

did not at the time know anything about the dental tissues, he at once acknowledged that the reaction in the dentine was inflammatory in its character. I asked him, "Are there any bacteria present?" He replied, "There are plenty, but the reaction of the protoplasm is so evident that I am perfectly convinced it cannot be from bacteria alone."

Dr. W. W. Walker. Gentlemen, our president, Dr. William Carr, has seen fit to provide, between the hours of six and eight o'clock this evening, a collation for our guests who have so kindly volunteered to come here from distant cities to assist in this debate. Therefore, if those who have been furnished with tickets will be kind enough to remain after adjournment of this meeting we will be very much obliged to them.

Adjourned until eight oclock P. M.

EVENING SESSION.

Dr. J. L. Williams. Mr. President and Gentlemen: I crave your kind indulgence just two or three minutes. There seem to me to be only two points in Dr. Heitzmann's paper that I care to make any reply to,—two points that seem to me so manifestly absurd that I must say just a word or two. I have cut a good many hundred specimens of pulps of embryo and adult teeth, and I never saw any different appearance from that presented there [illustrating on the blackboard] of the odontoblast layer of cells before the commencement of the process of calcification. There are present here at least four gentlemen who have made almost a life-study of this subject, and I think they will bear me out in the statement that in all the specimens they have cut they have never seen any other appearance than substantially that,—the cells having that form of a prolongation of the dentinal fibrillæ coming out from there in this manner, sometimes one, sometimes more, to the extent of a dozen, more or less. This is, as nearly as my memory serves, a representation of it on the board. May be Dr. Heitzmann has, but in all the specimens I have cut I have never seen an appearance like that which he has shown, not one; and I think the gentlemen who have spoken before me will bear me out, and say that they have never seen, after the commencement of calcification, an appearance like that. Now, in regard to the fibers in enamel. (You see I have a teachable disposition. I may remark that this drawing is after the improved style of Dr. Heitzmann.) Now, suppose the section of enamel represented had been cut directly through at the point which I indicate. This

represents a transverse section of the enamel, and these are the enamel-fibers cut transversely. This, Dr. Heitzmann says, is the position which the enamel-fibers occupy. Suppose the section should have been cut through there. The result would be that we would not have touched a single enamel-fiber. But the appearance is so nearly the same in the enamel-fibers that I am not able to detect the difference in appearance of that which he regards as enamel-fibers. You see it is almost impossible, on the theory of enamel-formation given in my paper, to cut a section and not get the appearance here shown. This represents a longitudinal section; this represents the intercellular formation,—interprismatic layer.

Dr. Atkinson. Don't say cellular.

Dr. Williams. Suppose we cut through here in this direction; the result is that we have cut two fibers; if we have been fortunate enough to cut straight through we will get the appearance of two fibers at that point; but nowhere else in this section will we get any appearance of fibers. On the contrary, the appearance is as represented here. But in all the longitudinal sections I have ever cut the appearance is substantially the same, and there is no possibility of explaining that appearance except that what has been mistaken for fibers is simply the interprismatic cement-substance which unites the cells in that manner.

Dr. Heitzmann. Dr. Williams certainly has made a grand improvement in that drawing. I claim the merit of that. That looks more natural than the specimen indeed. I do not know how Dr. Williams, who claims to have studied these things for several years, can change his mind in five minutes in that matter. I have not much to say about the correctness of this view, except I would add with red chalk a few corrections in the appearance of the transverse section. If Dr. Williams says this would be a longitudinal section, to use his own words, it would be absurd. If this is a transverse section, I presume that would be a longitudinal section; but the transverse section that he drew here with red chalk will correspond to the fibers running here.

Dr. Williams. Suppose it is cut in this point, here?

Dr. Heitzmann. You cannot cut such a section at all.

Dr. Atkinson. Extending between those yellow points through there.

Dr. Heitzmann. Certainly. That is what we claim.

Dr. Williams. Suppose this to represent a transverse section; if we cut in that direction, how can we get a single enamel-fiber?

Dr. Atkinson. That which has been called a fiber is the sheath that surrounds the fibril. Dr. Williams clearly showed in his first diagram that it was the enamel or organic matrix in which the in-

organic substance was deposited, and that you could not cut through there without coming in contact with and bisecting one of those.

Dr. Williams. That is the point.

Dr. Heitzmann. Dr. Williams maintains that if he cuts a longitudinal section it is impossible to see the enamel-fibers.

Dr. Williams. I say if it is made through this transverse section you cannot strike the enamel-fibers at all.

Dr. Atkinson. If the enamel-fiber does not involve the entire periphery of the prism.

Dr. Heitzmann. That is the point. There are fibers in the longitudinal section, but it is impossible to see the fibers everywhere. In no drawing that Dr. Bödecker ever made is such a relation present.

Dr. Abbott. Mr. President, in further answer to Dr. Williams, I will give as briefly as possible what I understand to be the manner in which the enamel and dentine are formed, and their destruction by caries. Then I will try and answer some of the points made by Dr. Sudduth. Instead of a *secretion* from the ameloblasts, as suggested by Dr. Williams, enamel is formed by the calcification of successive layers or rows of these corpuscles, and the reticulum of living matter contained in them is preserved and exists in the formed enamel. Dentine, likewise, is formed by the calcification of successive rows of odontoblasts, and the reticulum of living matter which is plainly visible in them remains as the living matter (Tomes's fibers) in the formed dentine. I will here state that I cannot conceive of the slightest injury to any living tissue, no matter where located or from whatever source the injury may come, without its producing an irritation of such tissue. The first lesion in the carious process of human teeth is a solution of the lime-salts of the surface of the enamel by some acid, generally produced by the fermentation of particles of food, saliva, etc. As soon as the living matter is reached it becomes irritated, which irritation if allowed to proceed soon assumes the condition of inflammation of that tissue, and advances along the enamel fibers *in advance* of the solution of the lime-salts by acids. When it reaches the dentine this inflammatory condition advances more rapidly, and is much more intense, in consequence of the greater amount of living matter to become affected. The lime-salts, after having been *dislodged by the swelling of the living matter*, are dissolved by acids and washed away. As they are carried away the reticulum of the former odontoblasts again presents itself and is eventually destroyed by putrefaction. During the latter process this portion of the decaying tooth becomes filled with "organisms of decomposition."

In the drawing which has been so timely exhibited by Dr. Sudduth

of a specimen sent him by Dr. Miller a zone or territory of inflamed dentine is plainly shown far beyond that occupied by organisms. This is the territory claimed by Leber and Rottenstein, and since by Dr. Miller and others, to be in a condition of decalcification by the solvent action of some acid. Now, this view, so far as I have been able to learn, is a mere supposition, its substantiation being based upon the experiments in "pure culture" conducted by Dr. Miller, and of course out of the mouth, which *proves* nothing as to the actual conditions in the mouth. The experiments of Prof. Mayr (*New England Journal of Dentistry*, Vol. ii., No. 1), which most emphatically disprove such a position, seem to be altogether lost sight of by these gentlemen. *It is a mistake on their part when they state that caries of dentine differs from caries of bone in that the process advances by the solution of the lime-salts and the subsequent destruction of the organic portion by organisms.* It is also claimed by these gentlemen that the usual features of inflammation are not present in a decaying tooth. I would ask, what portion of the organism is subject to irritation? Is it not the living matter? The heat, redness, swelling, and pain are effects, not causes, of inflammation.

It has been stated that we do not show our specimens. In answer I would state that they have been shown to every one who would take the trouble to look at them on every occasion that has presented itself; that Dr. Heitzmann has used them on all occasions in his classes, so that probably not less than one hundred gentlemen have become more or less familiar with their appearance under powers ranging from two hundred to fifteen hundred diameters. When Dr. Miller was here a year ago last summer he promised to send me some of his specimens for examination, but while he has sent them to others at different times none have come either to Dr. Heitzmann, Dr. Bödecker, or myself. I asked Dr. Williams to kindly afford me an opportunity to study the specimens from which these drawings were made; but no! Dr. Sudduth needed them at least a month to have drawings made which would take at most but a few hours to do. What does all this mean? We are accused of "forming a theory" in reference to the formation and caries of teeth to suit our peculiar ideas previously conceived. In view of these facts, I would like to ask if it would not be more in the interests of fair play, to say the least, if these gentlemen would take this charge to themselves. As far as the "cell theory" vs. the "bioplasson theory" is concerned, I hardly need refer to it, as my views upon the structure of tissues are well known to the reading portion at least of the dental profession.

President Carr introduced Professor R. R. Andrews, of Cambridge, Mass.

Dr. Andrews exhibited a number of stereopticon views of the development of the tissues of the teeth, and spoke as follows:

Gentlemen of the First District Dental Society: The invitation of your committee came to me in the midst of a very busy professional season. I fear that I have not had sufficient unoccupied time to do justice to your confidence. But the subject of the evening, "The Development of Teeth," is of such importance that I could not deny myself the pleasure of being with you, and I very cheerfully offer the results of my study.

Having become personally interested in photography, I have been enabled to prepare specimens of my collection illustrating this subject; and from the negatives of these photographs I have produced the lantern slides which are to be exhibited to you this evening. They do *not* show the details of a careful drawing; they *do* show the condition of the tissue as the microscope reveals it to us. I trust the demonstration which I am to give may make the discussion which is to follow more tangible to those of us who are not already familiar with the various stages of growth in a developing tooth.

At so early a period as the second and third month human embryos are rarely available for histological work; they seldom come to me in a perfect condition. I have, therefore, prepared my specimens from fresh embryos of pigs, in which the processes of development are nearly identical with those of the human embryo.

The tissues from which a tooth is derived originate in two of the three germinal layers. From the epiblast we have the epithelium; from the mesioblast the embryonic connective-tissue. In Plate I, Nos. 1 and 2, we see a mass of epithelial cells covering the embryonic connective-tissue. The darker line in the central portion of the picture, appearing to separate the two tissues, really belongs to the epithelium, and is its lowest and most important layer. From it come the first indications of tooth-growth. It has been called the mother layer; it is the stratum Malpighii. The cells of this layer are usually described as columnar or prismatic; at this early stage they are only approximately so. They vary from the spherical to the ovoid, and it is difficult to find the perfect columns shown in some illustrations. Another tissue has been spoken of as being very important during the early stages of development,—the basement membrane. I have never been able to demonstrate the presence of this tissue at this time, nor do I believe it has any influence whatever in the formation of a tooth.

Over that portion of the jaw corresponding to what will be the alveolar border, just prior to the appearance of the anterior enamel-organs, we shall find that the cells of the epithelium have multiplied

and are heaped up, forming what is known as the dental ridge of the authorities. The new cells seem to have their origin from the cells of the stratum Malpighii, and not from the central or cuboidal layer of cells. I think this is proved by the intensity of the stain taken up by the cells nearest the Malpighian layer, and by their being of a form nearer the simple bioplast. These are both evidences of new growth. The rapid increase of cells at this point has apparently forced the stratum Malpighii inwards, something like the letter V when the tissue is seen in section. This V-shaped groove [Plate I, No. 3] has been called, and by some recent writers, the primitive dental groove, but in the sense which they would convey it does not exist. Their error shows them to be students of a by-gone literature, and not searchers after actual truth from the living tissues. This folding in of the Malpighian layer extends but part way around the alveolar border. It is much more marked in the anterior portions of the jaw. The large increase of epithelial tissue at this point [Plate I, No. 8] has not been clearly accounted for, nor have the different foldings of the Malpighian layer. Many writers give these folds a significance which, as yet, I do not recognize. Those of us who have cut many sections from this tissue know that the enamel-organs of the temporary molars are formed where there is an almost *entire absence of either fold, groove, or ridge* [Plate III, No. 36]. May not the condition of the tissue at this time, during its very rapid growth, account for it. The expansion by growth of the surrounding tissue takes it all up, smoothing it all out.

> The crimpled petals in their prisoned bud,
> In time unfolding, form the perfect flower.

There are many folds at the base of the dentine-germ, just after calcification has commenced, which as yet have not been accounted for. I think they have only the significance of existence. [Plate III, No. 32].

Let us now pass to a consideration of the illustrations showing the various stages from the first appearance of tooth-formation to the perfected organ.

Plate I.

No. 1. Tissue from which tooth-structure is developed. The lower epithelial cells, shown by the dark central line, form the Malpighian layer, and separate the epithelial from the embryonic tissue below.

No. 2. An enlarged view of the same structure, with the Malpighian layer perpendicular.

No. 3. Section of lower jaw, showing the first stage in the development of the enamel-organ. The dental groove is here seen with

the enamel-organ budding from the right of it. The Malpighian layer at the right is not covered with its epithelial layer, it having been removed by the action of the knife in cutting the section. In this picture there is as yet no appearance of any formation of bone.

No. 4 shows the enamel-organ a little further developed, the epithelial covering being almost intact. Below the organ we see the first indications of the formation of the jawbone.

No. 5. The enamel-organ still further advanced in its growth by a multiplication of cells at the base of the organ.

No. 6 shows still further progress in the growth of the enamel-organ, the cells in its central portion having enlarged, causing it to assume a flask shape. The action of the knife has separated it somewhat from the tissue beneath, which shows beautifully the zone of embryonic tissue from which is to be developed the dentine-germ. [To place this view in the correct position, turn the top to the right.]

No. 7. The knife has here caused a separation of the dental tissues. The dentine-germ is here shown in the form of a papilla pushing up into the enamel-organ.

No. 8. Small view of the same, a little farther advanced, but from the embryo of a sheep.

No. 9.* Section of the lower jaw, showing a larger growth of the dentine-germ, capped by the enamel-organ, with part of the tongue at the upper right corner; the dark line at the left of the enamel-organ being the developing jaw.

No. 10.† Cross-section of the lower jaw and tongue, showing tooth-development in the second stage at the right, and in the third stage at the left.

No. 11. Enamel-organ and dentine-germ of a bicuspid or molar.

No. 12. Dentine germ, nearly surrounded by the enamel-organ, and entirely surrounded by the walls of the sacculus. On the left is seen a budding off from the enamel-organ. This is the germ of the enamel-organ of the corresponding permanent tooth. The walls of the sacculus are very finely shown in this section, and around this is seen the developing bone.

Plate II.

No. 13. Similar to the preceding, but farther developed. Calcification has commenced on the apex of the dentine-germ.

No. 14.‡ Developing molar of kitten with commencing calcification.

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* Section by Dr. Sudduth.

† Section by Dr. Sudduth.

‡ Section by Mrs. E. N. Whitman.

PLATE I.

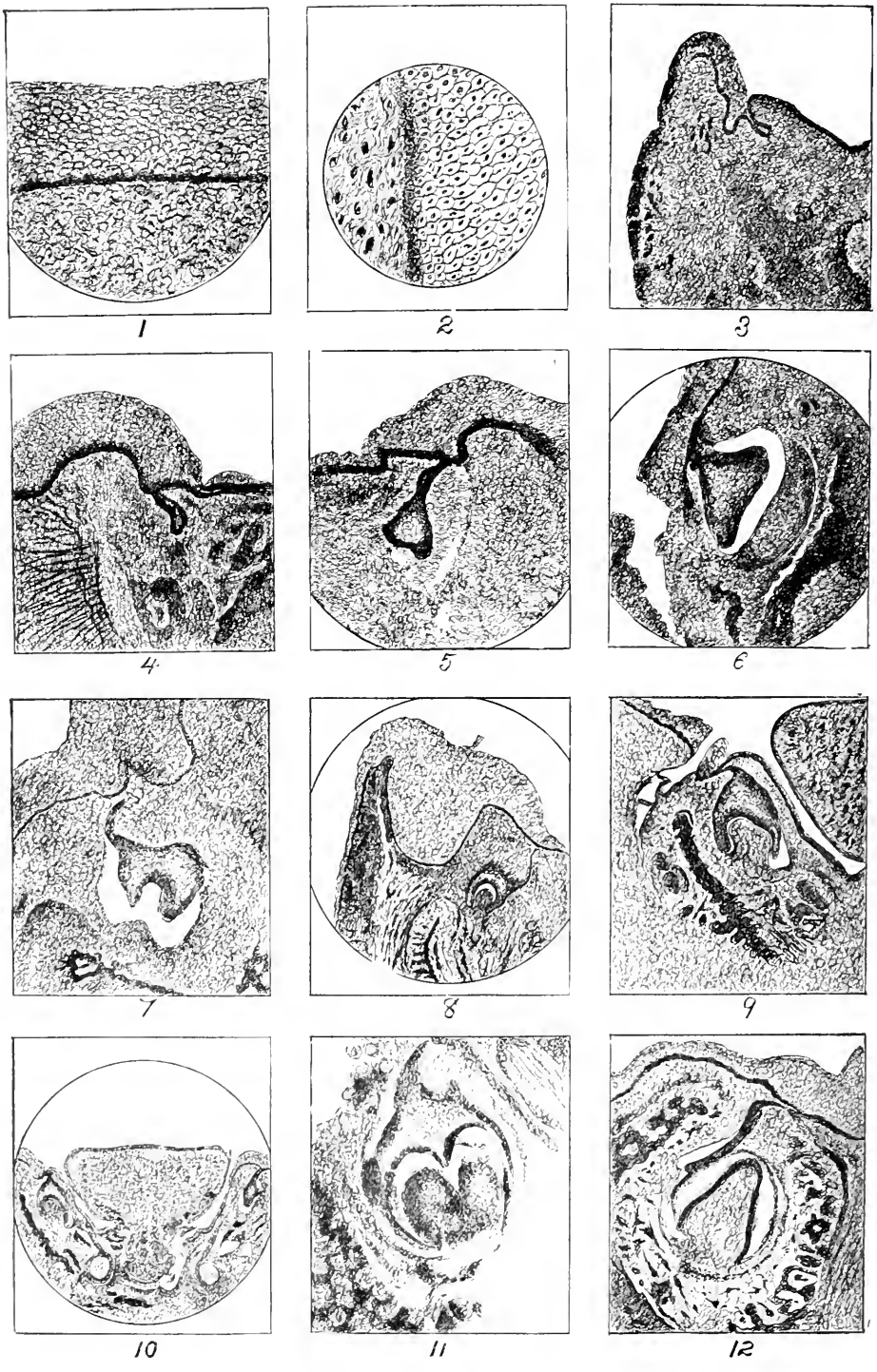
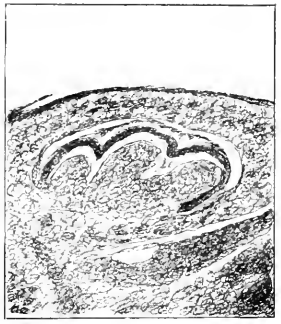


PLATE II.

13



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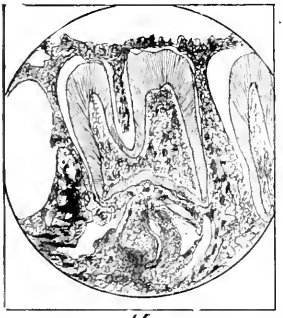

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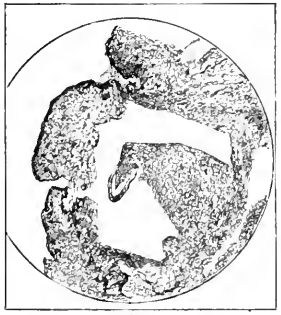

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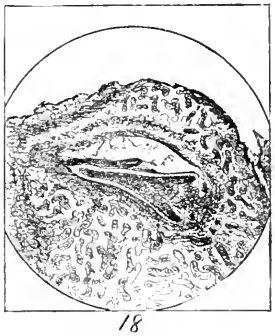

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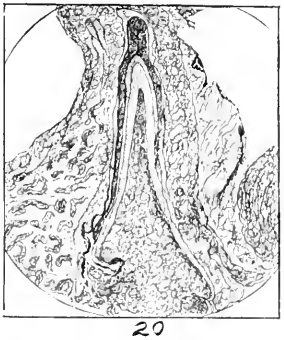

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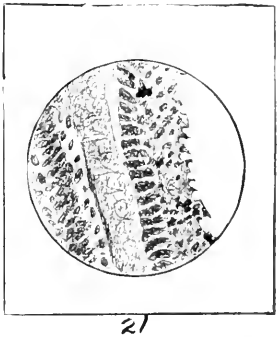

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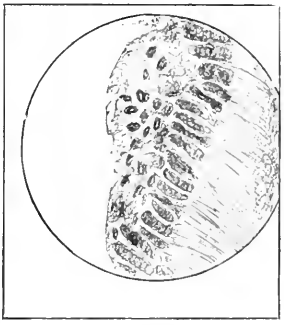

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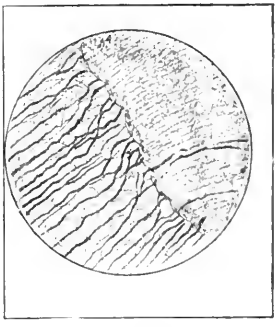

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No. 15. Here we have the breaking up into epithelial clusters of the cord which connects the enamel organ with the Malpighian layer. On the left is the permanent enamel-organ. The apex of the dentine-germ is covered with a cluster of enamel-cells, only a portion of the enamel-organ being present.

No. 16.* Section of rabbit's jaw, showing the temporary tooth, with the germ of the permanent tooth just beneath.

No. 17. Section of human jaw, showing calcification of the apex of the dentine-germ, all epithelial tissue having been washed away except the Malpighian layer.

No. 18. Section of growing tooth, with tissues teased out to show a fold of calco-globin between the calcified dentine and the layer of ameloblasts or enamel-forming cells. [To place this view in the correct position, turn the top to the right.]

No. 19. Section of growing tooth, showing folds at the base of the dentine-germ.

No. 20. Section of growing tooth with folds at the base of the dentine-germ, and folds of the calco-globin layer seen as a fine, dark line near the base of the dentine-germ, extending from the enamel which caps the apex of the germ.

No. 21. Greatly enlarged view of the odontoblasts or dentine-forming cells.

No. 22. Another view of dentine-forming cells.

No. 23. Another view of odontoblasts.

No. 24. Section of normal dentine and enamel, showing beautifully the termination of the tubuli at the junction.

Plate III.

No. 25. Cross-section of the tubuli of the dentine.

No. 26. Ameloblasts, or enamel-cells.

No. 27. Section of normal enamel; tooth of kitten. Shows clearly the enamel-rods.

No. 28. Crown of bicuspid showing evidences of calcification of the pulp.

No. 29. Root of bicuspid, showing hypertrophy of cementum, and dental excrescence or pulp-stone within the pulp-chamber.

No. 30. Jaw of kitten with teeth and tissues in place.

No. 31. Section of developing tooth, showing fold of calco-globin, which is a continuation of tissue from the forming enamel at the apex, between the formed dentine and the layer of enamel-cells or ameloblasts. To my mind this is a strong evidence that the enamel is a secretion rather than the direct calcification of the ameloblasts.

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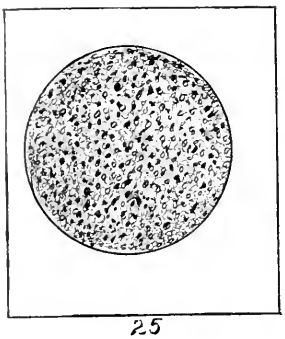
*Section by Dr. Sudduth.

PLATE III.



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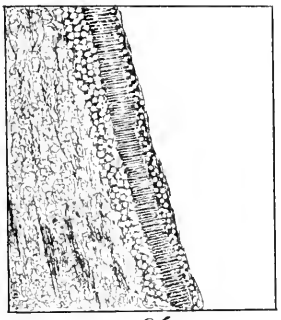

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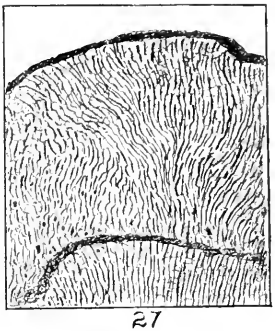

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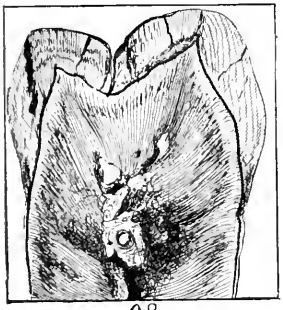

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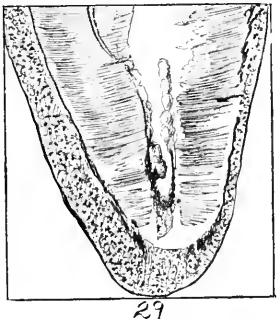

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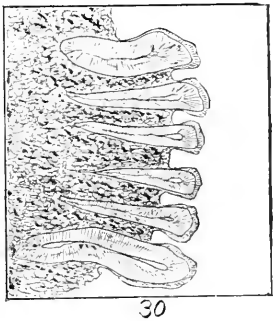

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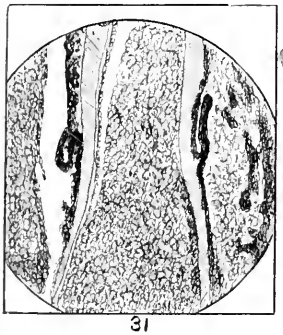

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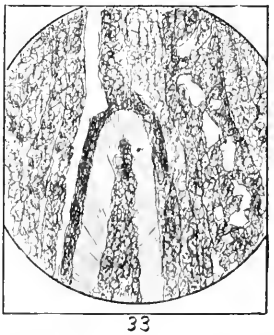

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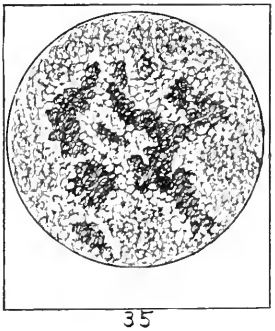

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No. 32. An enlarged view of the folds seen at the base of a developing tooth.

No. 33. View of the point of a developing tooth, with a fold of calco-globin faintly seen at the right.

No. 34. Haversian or vascular canal in human dentine running from the pulp-chamber toward the cementum.

No. 35. Section of embryonic tissue, showing differentiation of the cells into osteoblasts and formed bone. These are in clusters, which by calcifying form the jaw-bone.

No. 36. First stage in the development of enamel-organ, with almost entire absence of dental groove.

President Carr. Gentlemen, we have heard from Massachusetts, New York, and Pennsylvania, and now we will have the pleasure of hearing from the West. I will call on Professor Black, of Jacksonville, Ill.

Dr. G. V. Black. Mr. President and Gentlemen: This has been a funny meeting so far, and a funny discussion; but I hope you will not expect anything funny from me, because I am not a funny man. We have had here a repetition in its most essential phases of a discussion that occurred in London fifty years ago, and I suppose they were as well satisfied that their views were correct as we are to-day. Some peculiarities have entered into this discussion that did not enter into that. There were some quibbles over technical points that were different, not yielding exactly the same product, but the trend of thought in that discussion and in this was very similar, in that one party was arguing for the vitality of the dentine, and the manifestation of that vitality in its diseases; while the other party was arguing as earnestly for the chemical nature of those diseases, and that vitality at most only modified them.

Discussion involving these points has been going on from that day to this, one party losing ground continuously, and never taking a step forward; the other party gaining ground as continuously, and never taking a step backward. When Mr. Tomes came into the field he came into it—that is, before he began writing—as a vitalist. When our French investigator in Paris (Magitot) came into the field—before he wrote—he came into it as a vitalist. They both worked with an earnestness that perhaps has not been equaled by many workers in the dental profession, with certain results which you all know. They yielded continuously upon the one side, and went forward as continuously upon the other. We know the result to-day. Tomes, through his son, has yielded the last point. Our French brother has yielded all but one, and if God preserves him

he will soon yield that. Possibly the expression is not quite clear, as it stands in Magitot's work, but as I understand him he still supposes there is some resistance to the progress of dental caries by the vitality of dentine. It is very little that he has not yielded. This controversy was begun in earnest by Wm. Robertson, of Birmingham, England. There had been some skirmishing before, but the first big gun that was fired was by our friend Robertson, who wrote and published his book in 1835. Many men had talked and had published articles upon this subject before, but here was a book that, I may say, unsettled the world, and yet it never was fully received by the profession. The bottom facts were written down by him in such plain language, so true to nature, that it will yet be received. He was followed by Regnard, in France, in 1838, who perhaps wrote more exactly and more forcibly in relation to caries of the teeth—although in exceedingly quaint language, if his translator does him justice—than even Robertson. They agree precisely. Desirabode then took up the matter, denying the propositions of Regnard. At that moment the voice of the profession of medicine, and of dentistry so far as we can call it then a profession, was with Desirabode, and he seemed to succeed. Even then he brought up the old idea, so popular, that the decay began in the interior of the dentine, as a conclusive proof that decay of the teeth could not be caused by acids produced by fermentation. Now, gentlemen, I wish to speak of this matter of caries beginning within the dentine, not simply because those men thought so, but for another purpose. From the time of Hunter, or fifty years before,—one hundred years ago, if you please,—it was held by men who had made this subject a study that caries of the teeth—decay (I like that expression better)—begins within the substance of the dentine, and works its way to the surface, possibly to the pulp. You will all say, "What dunces! What nonsense!" Why should they have held this theory, and worked over it, and struggled over it, until the time of Robertson? For he was the man who broke the backbone of this foolishness, though others had denied it before him. Were they not men of good observation, of sound judgment, and were they not careful men, let me ask you? Will we say that Hunter was not a careful man, or that Fox was not a careful man, and many others whom I might mention? Now, what is my purpose in bringing this up? Simply to show that men whom we regard as exceedingly good men, whose opinions we value very highly, are often—what shall I say?—mistaken. At least, they have come to hasty conclusions. This was a thing, seemingly, that any man of reasonably good observation might have decided for himself. And yet that was the first thing that was thrown at Robertson, and was considered a strong argu-

ment. He denied *in toto* that any such thing could occur, because, said he, decay of the teeth is the result of fermentation, with the formation of an acid which acts upon tooth-substance, *and must begin upon the surface.* He could not explain fermentation in that day; the knowledge of the world was not sufficient to give a rational explanation of fermentation. They used the words "fermentation" and "putrefaction." It required all the work of Schwan, Schroeder, Pasteur, Lister, Koch, Miller, and others who have worked in that field, to give us a rational explanation of the process of fermentation. And that explanation has come; and if, as dentists, we do not understand it, we are to blame for it. It is a purely physiological process. As students of physiology we should study it, even if it were not related to us in another way. Physiology is one thing the world over.

This brings us to another point. Physiology in its principal points is the same throughout all the manifestations of life, and we must get down to bedrock in this matter—study physiological principles—if we would understand that which we see, and the diseases with which we must deal. Now I will get into trouble, for I know my friend over there will not agree with me in what I am about to say.

The cell is the unit of physical life. No matter whether that cell represents a complete individual as we see it in the amœba, or is a component of the complex individual, one among the multitude that make up the sum of the higher animal forms, or their individual parts, as we see it in the stellate reticulum of the enamel-organ, as depicted by my friend here on the blackboard. But then this doctrine has been taught so long and so well that everybody understands it.

Voices. Not much. Not in that way. That theory is exploded, etc.

Dr. Black. Everybody understands it,—outside of New York. I have said *the cell is the unit of physical life,*—I am not talking of spiritual life,—and it has certain characteristics in its dealings with matter which are common to all units of physical life that exist on this planet. These are its physiological attributes, and they may be summarized in four propositions.

First. Each cell is capable, when in contact with certain material, of furnishing or elaborating a substance capable of digesting food-material, or preparing it for absorption and assimilation. This you may call diastase, soluble ferment, unorganized ferment, enzyme, or by any of the words in use to represent the digestive agent.

Second. It is capable of assimilating the food so prepared. Assimilation results in growth.

Third. Every individual unit of life is capable of de-nutrition. This consists in shedding out, in the form of waste products, material that has once been formed into protoplasm, or used in connection with the nutritive process.

Fourth. It has the power of reproduction in a definite line of forms.

These four powers may be—yes, they are—varied widely among the different organisms with which we meet. They are capable of living on widely different foods, and the digestive agent elaborated is different—that is to say, adapted to the digestion of different foods. Then the waste products differ widely among the different organisms, and yet they have much in common, as we find them in the animal, the vegetable, and the so-called third class, the kingdom of the microbes. They are urea in the animal; alkaloids and the organic acids in the vegetable; the alcohols, organic acids, and the ptomaines in the microbes; alcohol as seen in the torula or vinous yeast fungus; acetic acid in the fungus of that name, and in case of another micro-organism, as the bacillus anthracis, it is a ptomaine that is exceedingly poisonous. This class we call septic poisons. When we see certain peculiar symptoms in connection with a wound we say septic micro-organisms have invaded that wound, and observation teaches us that the patient is in almost as much danger as if stung by a viper. These substances are in every case the result of re-moleculizations of matter under the influence of the vital processes of living cells,—and this is fermentation.

In this we have the explanation in brief of the process of fermentation which Robertson and his contemporaries could not explain. The organism which produces caries has been found, and its essentials of physiology made out; the waste product—lactic acid—found, and its action in the production of caries explained. Some seem to regard this as a new theory, but it is only the further development of the theory of Robertson, propounded in 1835,—namely, that caries results from fermentation, with the production of an acid that acts upon the lime-salts of the teeth, and *acts independently of the vitality of the dentine.*

Now, these propositions are true, not only of the units of life as represented in the lowly organisms, the microbes, but they are true also of those high in the scale of life as well. In the lower forms, where the cells fall apart, each performs all of these functions for itself; but in those organisms that are formed by the union of many units of life there is a certain dependence the one upon the other,—a certain tendency to divide the work,—a tendency to specialization and the formation of specialized organs. Each cell makes a part of a certain group composing an organ,—and we have one group forming

bile; another forming pepsin for the purpose of digesting food; another forming mucus; another separating the waste product of all (urea) from the blood; another doing this and another that in the general work of organism. Among these some little groups are for a time employed in building teeth. We find it stated by good authority in matters of physiology that these cells are never mixed up in the work they perform,—that each group attends to its own special duties. This leads to another proposition. *There is a certain impress made in the fertilization of the ovum or seed that preordains just how far this differentiation shall go.* Epithelium remains epithelium, though it is modified for the formation of the glands and various structures, including the brain, as my friend has stated (more properly the nerve or brain-cells, including those of the spinal cord), but never becomes connective-tissue. The connective-tissues, on the other hand, form the tissues of support and motion, and the blood vascular system, and never under any circumstances form epithelial tissue. There is a drawing on the blackboard representing the enamel-organ. We have heard this evening that these tissues get mixed up, or changed the one into the other. We have had a mixed representation of the manner in which these ingrowths from the epithelial layer come down into the connective-tissue; extend more and more as the cells are multiplied, and form the enamel-organ; and how that in doing so these cells put out processes and recede from each other, the processes extending across the spaces. You have heard the terms "myxoma," "myxomatous tissue," and the statement that this becomes connective-tissue. Oh, dear, that is too bad! I was sorry he said it. Where did it come from? From what tissue was it developed? What is its purpose and destiny?

We have heard during this discussion the parable of John and Bob. Now, let me say that these boys are at it in earnest, and they are after the old man, my friend here, and unless he gets his foot out of that rut [pointing to the illustration of the enamel-organ] the boys will catch him and use him up completely.

That is all I want to say about that, except that this statement seems to be an outgrowth of a doctrine that appears to have emanated from New York, and of which I want to speak while talking about the jumbling of cell-forms,—a doctrine, if you please, that denies the existence of the cell as an entity in physical life; depreciating it to the position of a mere node of the so-called reticulum of bioplasson; and asserts that this reticulum is the life, or the life resides in this reticulum; that this reticulum runs continuously from node to node, mixing in around in every direction, pervading in continuity the entire animal. The man, according to this view, is a great big amœba, reaching out his arms and legs—a great amœba, not made up of units, but one life throughout,—spiritually, perhaps.

Dr. Atkinson. Even so.

Dr. Black. But he is made up of cells; and each of these cells has its peculiar individual life. My friend says "No." He tells you he sees these protoplasmic strings with his microscope. Let me say that it makes but little difference what this or that man may claim to see. The important factor is the interpretation of the thing seen. The interpretation placed upon these protoplasmic strings is substantially that in them resides the life of the organism, and that these threads are continuous throughout, uniting the life in one continuous whole, and it is also a denial of the individual life of cells of which physiologists have claimed that the body of the man is composed. And in the book that my friend here has given to the world this is distinctly extended to the vegetable kingdom as well, and illustrations are given of these strings connecting the life of the vegetable cells. This doctrine must stand or fall not alone upon what this man or that may claim to see in his microscopic preparations, but upon the broader observation of physiological processes as well. To establish it, these different forms of observation must coincide in their results.

Now we are ready for some illustrations of physiological processes. First, in vegetable life. We will take a very simple thing, one that all of you can understand. I think you all know of the process of grafting of budding fruit-trees. All know of the bell-flower apple, and of the crab-apple. Now, a long time ago some man, seeing the difficulty of obtaining a given kind of apple from the seed, on account of the mixtures of pollen by which the flowers are fertilized, hit upon the conception of snipping off a little bud from the bell-flower tree—any kind of an apple will answer the purpose of illustration as well—and planting it in the tissues of the crab-apple. He knows nothing about cells or protoplasmic strings, but he snips off the little bud composed of only a few cells, comparatively, and plants it in among a multitude of cells composing the tissue of the crab-apple tree. He ties it—fixes it there—and hopes it will grow. It does grow. Now we have a few cells from the bell-flower mixed with the many of the crab-apple, and according to this string theory the life becomes one throughout. Our experimenter watches the growth of the little bud into a branch; after awhile a flower comes; and finally the fruit is developed. It looks like a bell-flower apple. It is a bell-flower apple, having the form and flavor. How is this? It is one life. The tree is a crab-apple tree, but the new branch is like the bell-flower, and the fruit is bell-flower. We see by this that while there is a physical union of those cells there is no life union. Each of the individual cells has a life of its own, and *its progeny retains forever the impress made in the fertilization of the seed;* no mat-

ter how often it may be transplanted to and mixed in with cells of a different nature. Therefore, the interpretation our friend places on the strings which he claims to see cannot be true.

Dr. Charles Miller. When you put the crab into the bell-flower what do you get?

Dr. Black. You will get the crab-apple every time. Now, an illustration in animal life. Let us suppose that by any kind of accident I have the skin torn off the back of my hand,—every bit of the epithelium is removed.

Dr. Atkinson. Every bit?

Dr. Black. Yes, every bit. Even the sweat-glands are destroyed, and no epithelial cells whatever remain. Now, we have certain cells in this body of ours that seem to be set apart for making repairs in case there is a breach of continuity such as this,—the wandering cells. They are continually creeping, amœba-like, through the tissues and floating in the blood-streams, and in case of such an accident they collect at the point, and are built up into granulations to fill the breach. But epithelium does not grow upon these granulations. What is the matter? We have heard this evening that epithelium produces connective-tissue, and on the same principle connective-tissue ought to produce epithelium when it is needed. The life is all one; there is no individuality! But it does not. The covering must await the slow process of the projection of the epithelium by growth from the margins of the wound.

Dr. Atkinson. You did not know how to treat it.

Dr. Black. We found out how to do it. We clipped off the epithelium from somewhere else, or from the body of another person, and stuck it down among the granulations. It grew from each point where we planted a few cells, and spreading out from these points soon covered the wound with new epithelium. It did not produce connective-tissue! At one time we had a negro with a great burn on his back. We clipped off little bits of epithelium from a white man and stuck them down among the granulations, and they grew. Now, if life is all one, if these cells have no individual life, the living matter of the cells grafted in should become mixed with the general life of that negro, and the effect would be imperceptible. But, no; the result was the production of a patch of skin just as white as that of the white man from whom it was taken.

This does not look much like sustaining the doctrine that there are no individual units of life that are maintained in the make-up of the individual man. That epithelium retains its individual life,—carries with it the impress made in the fertilization of the ovum from which the white man was developed, and carries its peculiar characteristics into strange places.

I think these illustrations sufficient to show you that this bioplasson doctrine will not bear the test of physiological scrutiny. No matter what claims may be made as to seeing this reticulum connecting the cells, the interpretation placed upon it is wrong, and all theories based upon it topple and fall to the ground.

Now, I want to talk of some other things,—this matter of the dentinal fibrils passing out between the odontoblasts. [Drawing on the blackboard, reproducing a sketch made by a former speaker of the dentinal fibrils passing from the pulp into the dentine, and passing between the odontoblasts, instead of arising from them.] You see these lines passing out between the odontoblasts with little offshoots here. Let me say that it required a hundred years of observation and discussion before a man arose who observed sufficiently well to declare that caries did not begin within the dentine. Should we fall out with a man because he is mistaken? No. We should hope that he will look further. This is the result of faulty observation. I have certainly done enough of this class of dissecting to have some right to speak. I had stained sections of teeth with chloride of gold, and studied them while my friend here was still in Europe making illustrations from sections cut from the frozen cadaver,—which, I must say, was a beautiful work, and I wish he had done more of it. And when this reticulum business was first introduced to the American Dental Association I had some chloride of gold stainings there to show. I remember that Dr. McQuillen made a speech about it at the time, and my brother here on my right and I got into a row about it.

Dr. Atkinson. I was there.

Dr. Black. And we have been good friends ever since. I know just how my brother got into this difficulty with the dentinal fibrils. His picture is made from a diagonal section, and it deceived him. He saw the things he describes, but he did not get the true view of them. But before asserting that the dentinal fibrils do not arise from the odontoblasts, as has been held by the best observers of the world, he should have obtained every possible view of them; he should have taken them apart one by one and examined them individually, so as to prevent all possibility of error.

Several Voices. It can't be done. Tell us how to do it, etc.

Dr. Black. It is a simple matter of technique. I can tell you how if you wish me to. When you have extracted a tooth, throw it at once into Mueller's fluid, and let it stay about a week. Then crack it in a vice. A little experience will enable you to split the tooth lengthwise without crushing the pulp. Now, catch the pulp with a pair of pliers, and pull it out of its bed. Some of the odontoblasts will adhere to the pulp, and the fibrils to a consider-

able length will be pulled out of the dentine, while some of the odontoblasts will remain, adhering to the dentine, with the fibrils pulled out considerably from the canals. By placing the pulp in a freshly-filtered solution of Mueller's fluid, and examining it with a good hand-lens, you can tell where the fibrils have pulled off, or remained attached to the pulp, by the fuzzy appearance of its margins produced by the fibrils. If it is found that some have adhered to the dentine, which is usually the case, you may put that part of the tooth into staining-fluid, and stain before removing them if you like. To remove them, take a knife with a rounded point with which you can plow along down that part of the canal or pulp-chamber in which the odontoblasts have remained; have fluid in the canal,—glycerine is the best,—and bring the blade down on a glass slide. You will be pretty sure to get a good many odontoblasts, and the most of them will hang together in flakes so that the individual cells cannot well be seen. Using now your dissecting glass, break up these with needles somewhat, or simply shake them about to detach any loosened cells; then lift out the larger flakes and lay them aside. Lay a cover-glass over the remainder, and examine it with a one-fourth or one-eighth inch glass. The chances are that you will find a considerable number of single odontoblasts with fibrils attached, that are four or five times as long as the odontoblasts; or the fibril may be short, or there may be no fibril at all; for in some cases they will not be stretched out in the canals in withdrawing the pulp. Some failures will be made, but usually it does not require many trials to get good views of these cells with a considerable length of fibrils. You never get the true form of the odontoblast in sections cut from tissues hardened *in situ*.

Now, as to the enamel and the diseased condition described here to-day, I do not care to talk. This interpretation is based upon the theory of protoplasmic strings, and of that I have said enough. If my friend here wants to picture wire screens all over his histological drawings, let him do so. It is not so much what one sees, after all, as his interpretation of what the tissues do, that is important; and of this I want to talk for a moment.

The odontoblasts line the pulp-chamber, or cover the tissues of the pulp, and their processes, the dentinal fibrils, extend into the dentinal tubes and through them to the periphery of the dentine. We have an affection beginning on the surface of the tooth; caries, or erosion, or absorption has exposed the distal ends of the fibrils. What is the result? We get hyperesthesia. Where do we find vital changes? John Tomes has been through this course of study long ago, and he began with the inflammatory theory. But he found that none of the elements necessary to produce the morphological

changes which we know as inflammation could get into the dentine. The leucocytes could not get in; the blood could not get in. No morphological changes of the tissue itself could be discovered that in anywise resembled inflammation. Therefore, he concluded that dentine could not inflame. Still, he was not willing to give up the idea, and he searched this tissue to see whether or not it manifested any changes peculiar to itself. And the more he studied the subject the less he found of the doings of vitality, until he yielded everything. Still, the dentine is sensitive, and sensation is a manifestation of vitality. It is a law of physiology that the processes of cells are especially receivers of impressions. This is most strongly manifested in the nervous system,—the nerves are processes of cells. But it is true of other tissues as well. Where is the pathological change accompanying that sensitiveness manifested? The dentinal fibrils reach through the dentine; they are processes of living cells; and the morphological changes are found in the pulp-chamber, in or about the cells of which the fibrils are processes. In one case of erosion the pulp lays down more dentine; in another the layer of odontoblasts becomes atrophied; in another the whole pulp may become hyperemic, etc. But you cannot demonstrate changes attributable to vitality in the dentine. Now, I know there have been some such claims based on the protoplasmic string notion, but these findings may be duplicated in teeth that have never given any history of disease whatever. The things seen were there from the time of the development of the teeth. It is another case of faulty interpretation.

The term "fixed material" has been used in this discussion. The term is a good one. What do we mean by it? The word *organic* is sometimes used to represent anything that has been built by the life-process. Fixed material is an organic material forming a part of the organism, but not possessed of life, and is incapable of performing any vital function. It is passive.

Dr. Atkinson. Tell me what you mean by life.

Dr. Black. That which does the four things I talked about a while ago.

Dr. Atkinson. Do you mean energy?

Dr. Black. No, sir; that word does not explain it.

Dr. Atkinson. What is life, then?

Dr. Black. I don't know.

Dr. Atkinson. And I don't know.

Dr. Black. These enamel-prisms are fixed material. This dentine, the hard portions, all except the dentinal fibrils, is fixed material, and is entirely passive. It may be acted upon, but it cannot itself act. We have had this afternoon a description of the forma-

tion of the enamel, and the organ which forms it, and have seen it illustrated by those beautiful photo-micrographs. It is formed from within outward, and the organ from which it has derived its nutrition has disappeared. The life-process has built this enamel,—laid it down there; and old Dame Nature, life, has stepped backward on tiptoe and gone off and left it, as a good mother would do with her sleeping child for fear of waking it; but, unlike the good mother, has never returned.

Dr. William H. Atkinson. I rejoice at the excellence of the various pronouncements that we have had before us to-night. I am happy in the growth that has been manifested, and I wish to bid God speed to each one who has spoken, in his effort to present the truth as it appears to him. Would that we were all large enough to enjoy the presentments and conclusions of our fellows, and not attempt to assert a domination over them. It would take hours to go through all that has been presented before us in an effort to harmonize the differences, albeit we are brothers, each seeking to give the highest expression to his apprehensions and interpretations. We should accord to every man the same liberty of interpretation of what he sees that we feel entitled to ourselves. The enamel-rod as here represented is to each individual truthful according as he sees it; but, if his attention has always been directed to one particular aspect, he is not likely to see so distinctly other aspects of it, and his ideas will depend on what he sees, and not upon all that is before him, and so his interpretation will be based upon what he supposed he had seen. My good brother Black still sees that which leads him to retain the old, mouldy interpretation of the effete cell-doctrine as to the primal steps in organization. Gentlemen, you had all better go to Carl Heitzmann's laboratory and get the true interpretation. You can see in Richard Owen's work a delineation of Max Schultz's thorns, because Owen's workmen cut sections and made drawings and engravings that properly represented the structure of the teeth, but for lack of discrimination Owen failed to describe in the text that which his pupils clearly delineated. What is that red line in the drawing? It is the representation of the fibril in partial view. The trouble with my brethren here to-night is that they have confined their attention to that portion of the presentment which met their vision. If the other part had been called to their attention they would have seen it. They said they were fibrils. Carl Heitzmann and I have had some combats with regard to what protoplasm is. I tell him these are nothing but little sacs of organized material holding a fluid substance differing in degree of life-endowment. He says the fibrils are living matter, and the intermediate

fluid is non-living. Dr. Williams makes his interpretation of what he sees, and Heitzmann makes a different interpretation. What will solder them together? This, I presume, is the periphery of the rod or prism that grows out of the ameloblast. Now, there is a calcific tendency in the protoplasm that loves aggregation, and the organizing presence in the animal economy consolidates the calcigerous structure, lining this impoverished portion that forms the periphery of the organ that is called inorganic, and that I call calco-globine. My brother said it was doubtful whether it was organic or not. It is so intimately combined with the animal elements that it cannot be discharged, even with hydrochloric acid. That is the increment of energy which awakens those beautiful six-sided prisms that we call the enamel-rods, and that remain perpetual in the enamel, and he leaves that out in the drawing.

And now, Mr. President and fellow-members and invited guests, we should be profoundly thankful for this unprecedented opportunity for comparison of views in the interpretation of microscopical presentments of the steps in formation, nutrition, and exercise of the factors of function in granules, molecules, corpuscles, organs, and systems, which make up the sum of our lives as individuals and as members of the human race. And in conclusion let me say that to Drs. Carr, Northrop, Francis, and Walker, who arranged this pleasant and profitable entertainment, the credit is due for its unprecedented success.

Dr. W. W. Walker. In addition to the regular papers and discussions, the committee has made arrangements for a microscopical exhibit. Notice has been sent to all who were to take part in the discussion to bring slides to demonstrate the points at issue. Mr. J. Grunow, the well-known optical instrument maker, of West Thirty-ninth street, has kindly sent up for our use microscopes and lenses, including his new one-twelfth oil im. For his courtesy we desire to express the thanks of the committee, and as well, I am sure, of all who are in attendance. Opportunity will now be given to those who have come prepared to present their slides. There has also been prepared up stairs a collation, to which all are invited.

[Dr. Sudduth spent an hour and a half exhibiting slides covering all the ground gone over in the papers read by Dr. Williams and himself. The slides shown included some which had been sent to Dr. Williams by Dr. W. D. Miller, of Berlin, showing artificial decay produced by the action of micro-organisms; and also some mounted by the exhibitor; showing tubuli distended and in some instances pushed aside by the growth of fungi. The exhibit was witnessed by a large proportion of those in attendance, who seemed to be deeply interested in examining the numerous slides submitted for their inspection.]

B. C. Nash, D.D.S., *Secretary.*